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The Influence of the Growth and Fattening Processes on the Quantity and Quality of Meat Yielded by Swine

E. L. SCOTT

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E. L. SCOTT

Submitted to the faculty of Purdue University, June, 1930, as a thesis in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

ACKNOWLEDGMENT

Appreciation is expressed to the Institute of American Meat Packers, without whose cooperation this work would not have been possible; to Messrs. H. C. Davison, E. N. Wentworth and A. T. Kearney, who gave considerable thought and time to the furtherance of the project; and to Kingan and Company and Armour and Company of Indianapolis and Swift and Company of Chicago, for the careful service rendered in connection with the collection of experimental data.

Professor F. G. King and the members of the Animal Husbandry Staff, Purdue University, contributed many helpful suggestions.

For advice and suggestions in regard to the statistical methods used in the analysis of the data, grateful acknowledgment is made to Dr. E. C. Young.

Dr. H. R. Kraybill, by his considerate counsel, and Mr. Harry W. Block, through his personal services, rendered valuable assistance in connection with the chemical phases of the investigation.

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THE INFLUENCE OF THE GROWTH AND FATTENING PROCESSES ON THE QUANTITY AND QUALITY OF MEAT YIELDED BY SWINE[1]

E. L. SCOTT

Department of Animal Husbandry

PART I

BRIEF REVIEW OF THE LITERATURE ON THE SUBJECT OF TYPE IN SWINE

In the past but little research has been directed at the problem of finding out the effect of the developmental processes on the quantity and quality of meat yielded by swine. There has been much speculation on the subject of which kind of hog will yield the highest percentage of loins or the best quality of pork. Considerable work has been done in determining the yields of different kinds of hogs at slaughter time, but little effort has been expended in studying the developmental processes of swine under corn belt farm conditions.

The world production of hogs amounts to about 260,000,000 head annually (32b). The number of swine on farms and elsewhere in the United States reaches an average annual total of almost 60,000,000 head (32a), and the industry returns a gross income of almost one and one-half billion dollars per year (31). Approximately two-thirds of the annual gross income from swine in the United States is returned to the nine states which include the corn belt area. Thus it can be seen that the magnitude of the industry is such that extensive research is justified, that the volume of business is sufficient so that even a very small saving per hundred weight would be of

[1] Submitted to the Faculty of Purdue University, June, 1930, as a thesis in partial fulfillment of the requirements for the degree of doctor of philosophy.

great economic importance, and that results secured might well be based upon data taken from corn belt laboratory animals.

In view of the tremendous volume of the swine industry it is almost incredible that so little research has been done on the dressing qualities of swine and that there is so meager an understanding of the influence of the type of hog on its meat characteristics.

Definition of Type

Type, as applied to the form or structure of domestic meat animals, is used to designate an ideal form, combining all the characteristics which contribute to the usefulness of the animal for the purpose designed. In swine, type should, therefore, refer to those characteristics of form which are associated with the economical production of good quality pork.

The classification of hogs into lard type and bacon type divisions is in accordance with the type divisions made in the other classes of livestock; for example, beef and dairy cattle, and wool and mutton sheep. Swine producers have come to use the word type, however, as a relative term for the purpose of designating the degree of size or scale of a hog within the breed. Thus, "Big Type" has been used to characterize the long-bodied, rangy, up-standing, late-maturing kind of hog, which has apparently shown a tendency toward greater scale and more ruggedness throughout. "Intermediate" and "Small" types are terms used to signify arbitrary groups or divisions farther down the scale of size. *Type in this sense carries the idea of a continuous gradation from the animal which is extremely small, short, and low-set when fully matured, to the one that shows tremendous scale and length of body and legs when developed to maturity. Throughout this publication, when type in regard to lard hogs is mentioned, this is the conception of type intended.*

More recently the term "Meat type" has come into use. The term is used to designate a hog which, when ready for market, will yield a high proportion of lean to fat—of meat to lard. This classification does not correspond to either of the divisions mentioned above, but refers rather to the fleshing characteristics of the hog regardless of his type classification.

History of Type in Lard Hogs

For an excellent presentation of a brief history of type in lard hogs the reader is referred to pp. 343-344, Bulletin 321, University of Illinois Agricultural Experiment Station.

Short, small, early-maturing, refined quality hogs were prevalent on farms and predominated in the show ring winnings until about the year 1908. At that time breeders began to select and breed the longer, rangier, later-maturing, more rugged kind of hog. This type reached the peak of its popularity in 1922 and 1923. The small, quality type hog of 1908 weighed only from three to four hundred pounds when fully matured and in breeding condition, while his descendant of 1923 reached a weight of from seven hundred to a thousand pounds, when in comparable finish, and showed other characteristics as strikingly different. This serves to call attention to the flexibility of the body form of swine, and to point out the fact that an established demand in pork products can be met from the present breeds of swine by careful selection and systematic breeding. It serves also to emphasize the need for fundamental information on the meat characteristics of our common breeds of hogs.

Tests of an economic nature, the results of which are dependent upon a number of inter-related and counter-opposing factors such as degree of finish, dressing percentage, type of hog, size of cuts, and comparative value of cuts at the time the tests are run, may be of economic value, but they do not serve to establish the basic principles upon which the results are founded. The premise that demand is transitional and that prices vary from time to time only serves to emphasize the need for information of a biological rather than an economic nature.

Production Phase

As early as 1917, Evvard and Culbertson (9a) started a series of experimental tests dealing with type in swine, with the idea in mind of determining "the relative gaining propensities, feed consuming ability, and feed requirement economy." These workers selected particular types of hogs, kept thirty-day feed records on litters from birth to maturity, and took individual measurements on the live animals to get com-

parative growth records each sixty days during the growth period. The results of their type test studies, as reported in their mimeographed series, No. D-95, November, 1923, show that big type hogs excelled the medium type, and the latter in turn were superior to small type hogs, in average daily gain, average number of pigs matured, and feed required for one hundred pounds of gain. There were represented in the table from which these conclusions were drawn 12, 46, and 9 big, medium and small type litters, respectively. The data covered the period from weaning time to an average final weight of two hundred pounds.

At the conclusion of their "typical litter comparisons" as presented in Leaflet No. 106, November, 1924, these same workers (9b) summarized as follows: "Our observations, experience, and controlled experimental data studies as we interpret them indicate that what is needed in now-a-day economic pork production is a combination of the smooth, thickly meated, capacious 'middled,' not too heavily boned Medium type conformation and the rapid growth impulse of the Big Type in the development of the superior swine which should develop rapidly with a near minimum feed requirement."

Carroll, Bull, and coworkers (5a) of the Illinois Agricultural Experiment Station in 1922 began a series of investigation involving five types of lard hogs; namely, very chuffy, chuffy, intermediate, rangy, and very rangy. They applied this classification to selected groups of live hogs. These authors concluded that type had no effect upon the rate and economy of gains. Their production studies were followed by a rather exhaustive study of the carcasses from the same experimental hogs. Carcass measurements showed that the length of head and neck and of legs varied directly with increasing type, but that length of body proper seemed to vary with individuals rather than with type. Conclusions reached by these workers in regard to quantity and quality of pork are cited under those divisions in this publication. Other general conclusions are quoted here:

"While type did not prove a controlling factor in the rate and economy of gains in these experiments, type did affect materially the quality of the pork produced. The results point to the *Intermediate* type of lard hog as the one best suited

for the present-day pork producer of the corn-belt, not because of any superiority in rate and economy of gains, but because the meat from this type more nearly meets the requirements of the present-day pork trade and consequently commands a higher price. No burden is put upon the producer in the production of the *Intermediate* type, since this type makes at least as large and as economical gains as any other type and there are more of this type than of any other on corn-belt farms today. It should be borne in mind, however, that future changes in consumer demand for pork may require further modifications of swine type to meet such demand."

Quantity of Yield Phase

In December, 1925, Wentworth and Ellinger (34), as a result of ideas gained from preliminary tests, conducted a packing plant killing test of two carloads of hogs, one characterized as long hogs and the other as short hogs. They concluded: "It appears that the long hogs yield more of the highest priced lean cuts, notably, loins and Boston butts. On the other hand, the short hogs yield more of the cheaper fat cuts, especially fat backs, bellies, and lard."

About the same time Hogan and coworkers (13), as the result of examinations of carcasses of bacon and lard type hogs, two each of which were slaughtered and analyzed at 100, 150, 200, 250, and 300 pounds, concluded as follows: "As the animals gained in weight, the shoulder and spare rib each made up a smaller percentage of the carcass. There was a tendency for ham and head to decrease also. On the other hand, both the bacon and loin constantly gained in relative size as the carcasses became heavier." And further, "The chemical analyses did not indicate consistent differences between the types."

In Bulletin 322, II, "Type in Swine as Related to Quality in Pork," Bull and Longwell (3a) summarize their data regarding percentage yields as follows:

"In the first and second experiments, when there were distinct differences between types, the carcasses of the Very Chuffy, Chuffy, and Intermediate types which were hand-fed in dry lot contained higher percentages of the fat cuts, such as leaf, fat back, clear plate, and belly, than the Rangy type

similarly fed. In the Rangy type the feet and picnics made up a larger percentage of the weight of the carcass than in the case of the other types. When self-fed in dry lot, the percentages of feet and picnics in the Very Rangy carcasses were greater than in the carcasses of the Intermediate type, and the percentages of leaf, fat backs, and clear plates were less. There was but little difference in cutting percentages between the Chuffy, Intermediate, and Rangy Types when self-fed in dry lot. In the experiment of the third year, when differences between types were not so pronounced, there were no differences in cutting percentages."

The United States Bureau of Animal Industry (21a) in 1928 cut 522 carcasses into standard cuts and classified them according to weight and sex. On the basis of the carcass weight they obtained a higher yield of ham, loin, rib, head, and feet in the light-weight hogs. The heavier and fatter hog carcasses excelled only in the yield of bacon and fat.

The Purdue University Agricultural Experiment Station (25) in 1927 called attention to the fact that virgin gilts, identical in age, breeding, feeding, and management and similar in type to their barrow litter mates of the same length, carry less finish, yield slightly less trimmed bacon belly and shoulder, dress fully as well, and show relatively more ham than do the barrows.

This result was verified by the United States Bureau of Animal Industry (21b) the following year. They found that sows cut out a higher proportion of ham and loin and a lower yield of fat and bacon than barrows.

More recently, Park (24), publishing in the National Provisioner, reported that sows yielded more ham than did barrows of the same weight and approximate type.

It is of interest here to note that Shaw (29) counted the numbers of pairs of ribs in approximately 4000 carcasses. He found that while most hogs had either 14 or 15 pairs of ribs, occasionally carcasses having 16 or 17 pairs of ribs were found.

Quality in Pork Phase

No attempt is made to present a complete review of the literature on the quality phase of the problem. In order that

the reader may be familiar with the most significant findings on the subject, a digest has been prepared. Only findings that are considered of vital importance, many of them verified by several investigators, are presented here. During the discussion particular references are made to publications which cover the subject in greater detail.

One of the most evident manifestations of quality in pork is the firmness of the meat. This quality can be attributed largely to the firmness of the fat tissue, which, in turn, is influenced, though not determined, by the composition of the fat within the cells of the fat tissue.

Much work has been done on soft and oily pork. Carcasses grading soft or oily incur a customary discount of from two to three dollars per hundred weight. When considered in the light of the number of soft and oily hogs marketed annually, the loss to the industry is a tremendous one (10a).

In dealing with soft pork it is found that the chilled carcasses do not become firm, but remain soft, shapeless, and unattractive in appearance. Fresh pork cuts, lard, sausage, and even the cured, smoked products, are shapeless, unattractive, and difficult to work with. Burke and Ewing (4a) report a net loss in the processing of firm pork of 2.4% as compared to 6.6% for soft pork and 3.5% for oily pork. Oily pork is greasy and unattractive. Oil drips from the meat during the processing operations, particularly when warm temperatures are incurred.

Early Investigations on the Deposition of Fat in Swine

The study of the deposition of fat in animals was begun as early as 1850, when Leibig (19) suggested that the fat of animals might be synthesized by the animals from carbohydrates in the diet. Lawes and Gilbert (17) fed pigs a ration of known composition and concluded that the excess fat formed must have been derived from the carbohydrates in the diet.

Wolffberg (35) in 1876 performed experiments with fowls that indicated the formation of glycogen from protein. The validity of this conclusion has been demonstrated by Külz, Voit, Lusk, and others.

That body fat may be derived from food fat was demonstrated by Hoffman (12), who starved an animal until practically devoid of storage fat and then fed it large amounts of fat. Nine-tenths of the fat recovered from the slaughtered animal must have come from food fat.

In 1899 Henriques and Hansen (11a) found that fat synthesized from carbohydrates gave a higher melting point than fat obtained from sources of food high in fat content.

In the latter part of the nineteenth century Lebedev (18) fed linseed oil, and later detected the presence of this oil in the fat of the animal so fed. Munk (23) in 1884 confirmed the principle established by Lebedev by feeding mutton tallow and showing that the deposited fat exhibited constants approaching that of the original mutton tallow.

Henriques and Hansen (11b) have shown that temperature is a factor in determining the firmness of fat laid down in an animal. Animals fattened in warm quarters deposited firmer external fat on the same ration than did similarly allotted animals kept under cool conditions. These same investigators (11b) found that the firmness of the fat varied with its location in the animal body. The external layer of fat showed a higher iodine number and a lower melting point than the fat in the layer just beneath it.

The Ration as a Cause of Soft Pork

About the beginning of the twentieth century much work was begun in determining which feeds or combination of feeds produce soft fat in hog carcasses. Investigations along this line have been carried on in Denmark, Germany, and Canada, as well as in the United States. The reader is referred to United States Department of Agriculture Bulletin No. 1407, pp. 4-7, for an excellent presentation of the most important results secured in these countries in connection with the effect of the ration on the firmness of the pork yielded by swine. It is sufficient here to say that barley, rye, ground milo, potatoes and numerous other root crops, palm kernel meal, cocoanut meal, cocoanut oil, milk, and meatmeal are feeds that apparently do not exert a softening effect on the fat deposited from them. On the other hand, when fed in certain rations

and under specified conditions, peanuts, soybeans, rice polish, rice bran, beans, linseed meal, linseed oil, sunflowers, sesame, chufas, and mast have been shown to produce a soft or oily condition of the fat.

Corn has frequently been shown to have exerted a softening influence on the pork produced from it. The softness of the pork produced from corn, however, is not marked and apparently does not extend beyond an intermediate grade of firmness. This is particularly true when corn is fed in a properly supplemented ration and other conditions are favorable to the deposition of firm pork.

Jackson (15) calls attention to the apparent relation between the high oil content of a ration and its effect on the resulting pork, liquid or soft fat being associated with soft pork.

Rothwell (26) has observed that any condition which tends to interfere with the normal metabolism of the developing hog, or to derange his digestive processes, may cause softness in the resulting pork.

Scott of Florida (28), Carroll and coworkers (3c) of the University of Illinois, and the United States Department of Agriculture and cooperating experiment stations (10b) have done work on the hardening of fat previously deposited from a ration causing soft pork. In general, the results agree that soft fat in hogs can be hardened to some extent by a finishing period on a hardening ration. The practice of hardening soft hogs, however, has not been proved an economic success. Recent work at the Illinois Station (3c) shows that soft fat produced by soybeans is not easily hardened by subsequent feeding.

Most of the experimental work on quality in pork being done at the present time is directed at the ration as an influence in producing soft pork. The most inclusive and far-reaching experimental evidence on this kind of work has come from the United States Department of Agriculture and cooperating state experiment stations. Hankins, Ellis, and coworkers (10c), reporting on these soft pork investigations, point out the fact that there is a direct relation between immaturity and softness in pigs, that the initial weight of the experimental animals, the rate of gain made by them, and the quality and quantity of fat in the ration are factors that influence the firm-

ness of the resulting pork. As a result of their studies, Hankins and Ellis (10d) make the following statement in regard to the relationship of the ration to the incidence of soft pork: "Feed is generally recognized as the cause of soft pork. If certain feeds could be eliminated from the American hog feeding process the soft pork problem would largely disappear."

Burke and Ewing of the Texas Agricultural Experiment Station (4b) concluded that hogs which have been fed similar rations frequently chill out differently, and the same ration apparently may produce both hard and soft pork. "The results of this and former tests indicate that such a condition may be expected and suggest strongly that other factors than feed are probably of importance."

Immaturity and Soft Pork

Shutt (30a) in 1901 concluded that the fat of very young pigs and animals of unthrifty growth is softer than that of finished pigs that have increased steadily to the finishing weight. He found that most of the Canadian soft bacon came from immature or soft pigs.

That the fat of an animal becomes harder as the animal increases in maturity was brought out by König and Schluckebier (16). Ellis and Hankins (8) in 1925 verified this conclusion and found an increase in fat deposition, an increase in total saturated fatty acids, a decrease in content of unsaturated fatty acids and a decrease in the refractive index of the fat. Anderson and Mendel (1), working with albino rats, observed a decrease in the refractive index with increasing weight. Echstein (7) maintained that this lowering of the refractive index is dependent on the diet alone, and not on the weight or maturity of the animal.

In 1927 the Purdue Station (27a) called attention to the indication that the later maturing types of hogs require a thicker layer of fat to insure firmness than do early maturing types.

Bull and Longwell (3b), on the basis of the percent of fat in carcasses of 225-pound hogs of different types, found that six of the eighteen intermediate hogs hand-fed in dry lot were not finished at that weight, while none of the seventeen hand-

fed rangy hogs were finished at 225 pounds. The grading record on wholesale cuts from the unfinished, rangy hogs frequently carried the comment, "soft" and "poor quality" or "too thin." Self-feeding improved the quality of the rangy type, but hogs of the very rangy type did not finish when self-fed to 225 pounds liveweight.

Chemical Maturity

Moulton (22) has found that mammals show a rapid decrease in relative water content and increase in protein and ash content from earliest life until the time of chemical maturity is reached, at which time the change becomes less marked and a nearly constant composition is shown. According to his results, chemical maturity in swine, judged by ash analyses, is reached at approximately 150 days, while on the basis of the nitrogen and water content it appears to be reached at from 150 to 300 days.

Mitchell and Hamilton (20a) state that after pigs reach a weight of 150 to 175 pounds, corresponding to an age of 25 to 30 weeks, under ordinary conditions of feeding, the composition of the pigs on a protoplasmic, or fat free, empty weight basis appears to be remarkably constant and to be unaffected by the system of feeding.

THE PURDUE EXPERIMENTAL PLAN

Early in 1926 representatives of the Institute of American Meat Packers and of Purdue University, recognizing the need of carefully controlled research work relating to the killing qualities of hogs with known records of production, entered into a cooperative agreement whereby the study was undertaken at Purdue University.

Object of the Experiment

The object of the experiment was to study the effect of breeding, type and rate of gain on the quantity and quality of pork yielded by swine, and further to determine the fundamental relationships governing the dressing qualities of hogs.

The object of the experiment had as its economic aspect the idea of finding out which type of hog it is best to produce for

the benefit of the swine industry in the United States; in other words, which type of hog is economical from the standpoint of the producer and will also satisfy the consumer demand for pork. The answer was to be sought not in terms of the dollar value under the present set of conditions, but rather in terms of production factors and dressing qualities of different types of swine.

Experimental Premises

One of the premises upon which this experimental work was based is that volume data statistically analyzed tend to eliminate the effect of miscellaneous and uncontrolled factors.

Another premise, that rate of gain, other things being equal, is a good index to economy of gain, was made use of in selecting the experimental animals. This premise has been accepted so long that it has become an axiom among experiment station workers, and frequent reference is made to it in animal husbandry literature.

Evvard and coworkers, publishing in the Proceedings of the American Society of Animal Production (9c), give the following information on rate and economy of gain. Two fairly homogeneous groups of lots of hogs, forage and dry lot fed groups, were divided into average initial weight allotments of five-pound intervals. Correlations calculated according to the method of multiple and partial correlation were found to be $-.66 \pm .03$ for the forage lots and $-.78 \pm .02$ for the dry lots. To quote these authors, "This is conclusive evidence that the feed required for 100 pounds of gain decreases, rather rapidly, as the average daily gain increases."

Carroll and coworkers (5b) made a study of the relationship existing between rate and economy of gain. They have arranged their results in tabular form as follows:

No. of Pigs	Section of Gain Correlated	Coefficient
174	70–125 lbs.	$-.526 \pm .037$
155	70–175 lbs.	$-.523 \pm .039$
133	70–225 lbs.	$-.565 \pm .040$
174	125–175 lbs.	$-.811 \pm .018$
152	125–225 lbs.	$-.778 \pm .022$
152	175–225 lbs.	$-.904 \pm .010$

These correlations furnish some concrete evidence which would indicate that the premise is well founded and that, therefore, the more rapid gaining litters are, generally speaking, the more economical from the standpoint of the producer.

Since the Hoosier Ton Litter Club (14) afforded a source of experimental material on which breeding records, history of production, rate of gain, and other data were available, it was decided to select as experimental material only those litters which reached a weight of 1600 pounds or over in 180 days from the date of farrowing, this production record being considered sufficient evidence of ability to make rapid and economical gains. Further, such hogs are marketed at an age corresponding approximately to chemical maturity as found by previous workers (20a) (22).

Plan of Operation

The experimental hogs were slaughtered during four successive slaughter seasons, 1926 to 1929, inclusive, at the Indianapolis plants of Kingan and Company and Armour and Company. Each individual hog was handled as a separate test and was subjected to a detailed study in an effort to determine his dressing qualities.

The data collected were grouped into three main divisions: (1) The production and marketing record of the litter. (2) The killing data. (3) The cutting data.

The first group of data included the breeding of the litter, date farrowed, number, sex and earmarks of the pigs, qualitative rations fed, production management, number of pigs, and weight at 180 days after farrowing. Marketing date and conditions were also included.

The essential items included as killing data were individual liveweight of the hogs, sex, experimental number assigned, and condition and type estimates. Litter killing data recorded were weights of livers, hearts and gullets, internal fat, leaf lard, ham facings, and kidneys. The individual items recorded at killing time also included the weight of head.

Cutting data were recorded on an individual basis entirely. They included carcass measurements and weights of each cut product of the hog.

The original experimental data are not included in this report. All data collected in the experiment are available in the

data files of the Animal Husbandry Department, Purdue University.

Routine System of Handling Animals to Be Slaughtered

The hogs were received at the Indianapolis Union Stock Yards, usually within a few days of the 180th day after farrowing.

With the exception of 213 hogs, 24 litters slaughtered in 1926, all hogs were given a corn and water fill at the market. Special consideration has been given to these litters wherever the market weights were used in the calculations.

The market weights of the litters were recorded at approximately nine to ten o'clock in the morning. The litters were then transferred by truck to the holding pens at the packing plant, where they were held without feed until the following day. Individual liveweights were taken prior to slaughter, and the animals were killed during the forenoon of that day. Figure 1 shows a number of litters that had been killed and were awaiting removal to the coolers.

At the time the individual weight was taken, the identity of each hog was established and maintained until all of the data had been collected and its cuts were removed from the cutting floor. This identity was accomplished by tattooing an experi-

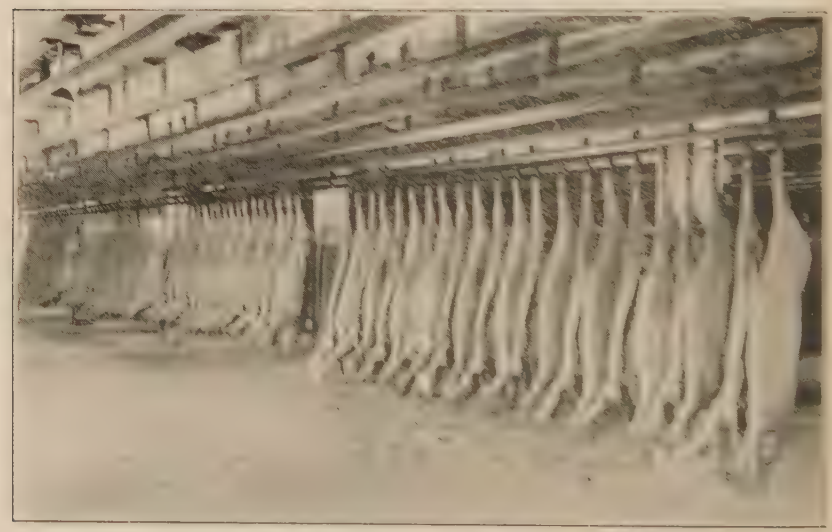


Figure 1—A number of the experimental litters ready for the cooler.

mental number into the skin of the hog. By means of a rubber stamp and "inspectors' ink" this number was transferred to the head and to each wholesale cut of the carcass.

Warm carcass weights were taken on each hog. The carcasses were given a forty-eight hour chill and a weight of the chilled carcass ready for the cutting table, that is, with the head, leaf lard, ham facings, and kidneys removed, was taken. The weights of the cuts and trimmings from a carcass were checked to within one pound of the weight of the chilled carcass. After the necessary weights and measurements had been taken, the cuts were disposed of through the usual channels in the packing plant.

Carcass Measurements and Method of Cutting the Carcasses

For convenience in calculations, the measurements taken during the course of this experiment were recorded in centimeters. These measurements can be converted directly into inches by dividing by the factor 2.54. Only one carcass side of each hog was measured. Figure 2b illustrates the measurements that were taken on the carcasses.

The rib-to-aitch measurement was taken from the front edge of the cut surface of the first process, anteriorly, on the cranilifern cartilage to the posterior portion of the exposed aitch bone. The aitch-to-toe measurement extended from the latter point on the aitch bone to the tip of the hind toe. In measuring the depth of chest the steel tape was held perpendicular to the carcass side at the point of greatest chest width. The depth of chest measurement is not a very satisfactory one, since it will vary with the position of the carcass and also with the covering of fat carried by the carcass.

The carcasses were all cut into standard domestic wholesale cuts. They were cut as "loin" hogs; hams, American cut, three fingers from the aitch bone; bellies, square cut and seedless; and two and a half rib shoulders cut into Boston butts, clear plates, picnics, etc. With the exception of the 213 carcasses studied in 1926, all carcasses were cut and trimmed according to the method of one of the large packers under the supervision of an expert cutter furnished for the purpose. Figure 2a illustrates the method of cutting used in the experiment.

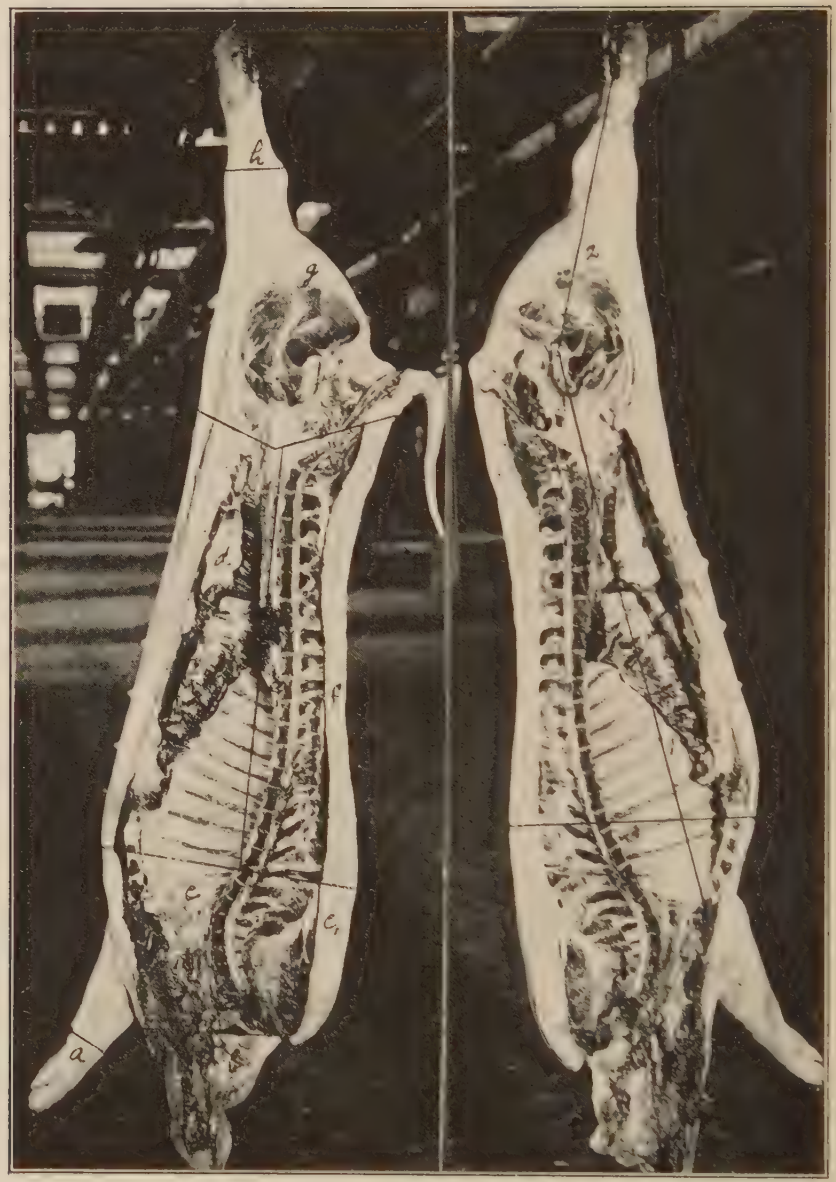


Figure 2a — Lines representing cuts made to divide the carcass into wholesale cuts: (a) fore shank, (b) jowl butt, (c) shoulder (c_1) shoulder fat, (d) side, (e) loin, (f) fat back, (g) ham, (h) rear shank.

Figure 2b—Lines representing actual measurements taken on the carcass side: (1) rib to aitch, (2) aitch to toe, (3) depth of chest.

Weights and Measurements of Wholesale Cuts

Weights were taken of each of the cut products from every hog. These weights were recorded in pounds and ounces and were later converted into pounds and tenths. All weights were taken on special experimental scales which were serviced as often as necessary to insure accuracy. Further, the weights of the cuts from a carcass were checked against the weight of the carcass.

The depth of fat as an index to the covering of fat carried by a hog was taken at the butt of the ham directly lateral to the protruding end of the ilium bone. The taking of the thickness of the ham and of the shoulder on both the right and left sides of the carcass was accomplished by means of a square equipped with a movable perpendicular bar. The ham measurement extended from the anterior portion of the cut edge of the aitch bone to a point on the outside of the ham directly lateral to the aitch bone—the point of greatest width. The shoulder measurement extended from the sawed surface of the back bone opposite the third rib to the point of greatest thickness through the shoulder. The length of loin measurement was taken from one end to the other along the flat surface where the spinal column was split.

The method of cutting used separates the carcass into three general types of cuts; namely, fat, lean, and bony cuts. The fat back and clear plate, or shoulder fat, consist entirely of the external fat layer with little or no lean attached. The loin and Boston butt likewise are composed almost entirely of lean meat, together with more or less bone. The neck bones, spare ribs, and fore and rear shanks are preponderantly bone in substance. The hams are largely lean meat, with a covering of fat tapering in thickness from butt to shank. Although the bacon sides are streaked with lean meat, they are primarily fat and are classed with the fat cuts. Thus, it can be seen that in an analysis of the carcass for percentage yields, these types of cuts can be used as an index to the relative proportion of lean to fat shown by the carcass being studied.

Grading the Carcass and Sampling the Fat

After a forty-eight-hour chill, and while still at an internal temperature of approximately 32 degrees Fahrenheit, the carcasses were examined for evidence of softness. At the same

time samples of fat were taken for analysis in the chemical laboratory.

Volume and Character of Data Secured

During the progress of the experiment 997 hogs were slaughtered and subjected to a detailed study on an individual basis. The animals slaughtered were classified into two general classes: namely, strictly lard hogs, and all other hogs, a group which comprises the so-called general purpose breeds as well as bacon type hogs and their crosses. Table I shows the number of litters and hogs slaughtered in the project, together with their breeding.

TABLE I—Breeding, Number of Litters, and Number of Hogs Slaughtered

Breeding	No. Litters	No. Hogs
I. Strictly Lard Hogs:		
Duroc Jerseys	27	243
Chester Whites	10	96
Poland Chinas	7	53
Spotted Poland Chinas	1	10
Crosses between these breeds	34	308
Total	79	710
II. All Other Hogs:		
Hampshires	4	35
Berkshires	3	26
Tamworths	5	43
Yorkshires	1	6
Crosses between these breeds	18	177
Total	31	287
Total Slaughterings	110	997

Rations Fed

An examination of the feed records of the litters slaughtered in the experiment brings out the fact that all the litters were fed substantially the same ration. The litters were full-fed a well balanced ration. For the most part the rations fed were composed of corn, tankage, and clover or blue grass pasture. The only rations listed which might be expected, in the light of our present information, to produce soft pork, were fed to two litters that received some soybeans. The amount of soybeans fed, however, made up so small a part of the ration that they apparently had no detrimental effect upon the pork produced. Four of the litters slaughtered received

hominy hearts, or hominy feed, as the major carbohydrate portion of their ration. These litters invariably showed a high proportion of soft carcasses, a fact which indicates that hominy feed may have a softening influence upon the pork produced from it.

Character of Data

The animals used in this experiment constitute a rather highly selected sample. The litters were grown in an area contiguous to Indianapolis wherein there are no major geographical or climatic differences, were full-fed well balanced rations, and showed extremes neither in type nor in rate of gain. Although there is reason to believe that the principles brought out in the data are of general application, the interpretation is restricted to the material herein described.

Method of Analysis of the Data

The data here presented are analyzed on a volume basis. Many of the variables involved are not controlled, but the volume is sufficient when properly handled to eliminate or control to a large extent the effect of such variables. Since the processes being studied are developmental in nature, the results are studied by means of lines of averages, using the method of least squares. For the most part, the relationships have been established as rectilinear, and for this reason straight line trends or lines of average relationship have been employed extensively. The equation for the straight line trend, or line of averages, expresses mathematically the average relationship between the two variables being studied. It is fitted to the data in the correlation distributions by the method of least squares.

About these lines of averages the data almost invariably show a wide distribution, and the generalizations can be considered to hold only when studying large amounts of data. The lines should be considered as lines of average relationship which, together with the statistical measures given, constitute a description of the average situation. Factors not taken into consideration in the comparison being made, or unknown factors such as individual differences, cause considerable variation about the lines. The basic principles, however, are established, and, when properly interpreted, provide information upon which to base future experimental work and commercial operations.

Part II

QUANTITY OF PORK YIELDED BY SWINE

PRODUCTION STUDIES

Length-Type Classification

One of the problems being considered in this experiment is that of type in lard hogs and its relation to economical pork production. This involves a study of the production records or quantity yields as well as the percentage yields and the quality of the pork.

To separate hogs into definite type classes, and to be able to describe the types being discussed in such a way that others can get a definite idea or picture of those types, is not an easy matter, particularly with live hogs. Previous studies have relied largely on judgment as the basis of type classification. However, Mitchell and Hamilton (20b) of the University of Illinois made use of a type index which was computed in such a way as to measure the proportion that an animal would fill of a rectangular solid determined by the animal's dimensions. This type index was taken as the ratio of the volume of a rectangular solid equal to $H^2 \times L$ to the volume of the animal obtained from its weight and specific gravity. For hogs of a given type this index varies somewhat with the amount of fat carried.

For the purpose of this study it was considered practical to use as a basis for separating hogs into types certain carcass measurements supported by the judgment of the operator in regard to type. Since the hogs slaughtered in this experiment were full-fed well balanced rations, responded with a high average daily gain, and had all reached an age of approximately six months, it is likely that there was little difference in the opportunity to secure maximum skeletal growth.

Since type in lard hogs implies to some extent ranginess or height from the ground as well as length of body, the combined age-corrected measurement, rib-to-aitch plus aitch-to-toe, was made one basis for a comparative index of the type of the hog. The animals included in the various groups by this method of classification do not vary greatly from a

division based on length of body alone. The data in Table 1, Appendix II,* show a very close relationship between the rib-to-aitch and aitch-to-toe measurements.

Inasmuch as the experimental animals were slaughtered at an age of from 170 to 203 days, centering about a mode of 180 days, these measurements were age-corrected to 180 days. An approximate age correction was arrived at by subtracting the average measurement of a new-born pig from the corresponding carcass measurement, dividing the resulting quantity by the number of days from farrowing to market, and using this average daily length increase to reduce or increase the actual measurement to the 180-day age-corrected measurement. The age-corrected rib-to-aitch, aitch-to-toe measurement of the individuals showed an arithmetic mean length of 128.81 ± .090 centimeters.

For the purpose of showing the application of the principles indicated in the type correlation distributions the lard hogs were divided into three type groups. A study of the live hog type estimates showed that those 180 day old experimental hogs which were estimated as Medium Plus or Medium Big in type, showed average age-corrected rib-to-aitch, aitch-to-toe measurements of about 134 or more centimeters. Medium Minus or Medium Small hogs usually showed measurements of less than 124 centimeters. Since there is no definite biological division of types, and since human judgment is subject to error, it was decided to divide the types on the basis of carcass measurements, setting the limits of the type groups such that the three resulting groups would agree reasonably close to the Medium Big, Intermediate and Medium Small type classification used in practical animal husbandry parlance. All hogs which fell within five centimeters of the arithmetic mean were included in the Medium group. Those hogs of 133.81 centimeters or over were designated as the Medium Plus group, and those showing a measurement of less than 123.81 centimeters were classed as Medium Minus hogs.

The extent of the degree of agreement between the type classification based on length measurements and on type estimates of the live animal is indicated by the fact that of the 135 hogs comprising the resulting Medium Plus group 86, or

* Tables in the body of the manuscript are numbered with Roman numerals, while those in Appendix II are designated by the use of Arabic numerals. See page 68 for explanation of data included and symbols used in Appendix II.

63.7%, were estimated as at least Medium Big type on foot. This is considered a reasonable agreement since the hogs were studied at different times over a period of years, since a certain amount of shifting from one side to the other of such an arbitrary line is to be expected, and since some variation in the individuals included in the resulting type groups due to differences in growth is unavoidable.

Neither the extremely rangy, big type nor the exceptionally short, chuffy type were represented in the experimental hogs.

Although it is realized that length measurement and rate of gain are associated to some extent, the data on rates of gain by length-types of lard hogs are considered of value. A few marginal hogs fell to one side or the other of the line of division between the different types because they did or did not grow fast, but for the most part the method used divided the individuals by litters or breeding.

Average Daily Gains

Although extremes in types are not included in the data, within the range of type incurred here there is evidence that the bigger the type of hog, the more rapid was the average daily gain.

In Table II are given the average rib-to-aitch plus aitch-to-toe measurement, liveweight, daily gain and depth of fat for the three length-types of lard hogs.

TABLE II—Gains Made by Length-Types of Lard Hogs (Individual Basis)

Group or Type	No. of Hogs	Ave. Length R-A + A-T (cms.)	Ave. Live-weight (lbs.)*	Av. Daily Gain Farrowing to Market (lbs.)*	Av. Depth of Fat (cms.)
M+	135	137.83	225.24	1.22 ± .007	3.4
M	397	128.85	201.77	1.09 ± .004	3.4
M—	127	118.87	187.11	.96 ± .006	3.3

*135, 354 and 113 hogs, respectively, are represented in these two averages.

Since the more rapid gains made by hogs are closely associated with the most economical gains, the average daily gain from farrowing to market is considered the most important production data presented above. On the basis of the probable errors of the means and of the differences these data carry significance.

The litter production data for these same hogs is presented in Table III. The division of the litters into three type groups was accomplished by arranging the average litter lengths into an array and dividing them into three equal groups on the basis of an equal number of litters in each group. This grouping merely narrows the range of the intermediate class in order that the other two classes may contain an equal number of litters. In consequence, these groups manifest accordingly less difference between the averages for the three groups.

TABLE III—Gains Made by Length-Types of Lard Hogs (Types Divided by Litters)

Group	No. Litters	No. Pigs Farrowed	Av. No. Pigs In Litter At 180 Days	Av. 180-Day Weight per Hog (lbs.)	Av. Daily Gain per Hog—Farrowing to 180th Day (lbs.)
M+	20	226	10.50	217.37	1.21
M	19	216	10.11	206.00	1.14
M—	19	216	9.95	189.88	1.05

These data tend to substantiate those in Table II, and to show how closely the litter production statistics agree with the results on an individual basis.

The data in Tables II and III indicate that within the range of length-type in lard hogs incurred in these experimental animals, the longer, the later maturing, and the bigger the type of hog, the more rapid was the daily gain. In order to bring out more clearly this relationship a simple correlation between the two variables, length and rate of gain, was prepared. These data are found in Table 2, Appendix II. The coefficients of relationship, .618 ± .017, should be noted and the distribution studied, bearing in mind that the Medium Minus hogs show a rib-to-aitch, aitch-to-toe measurement of less than 123.81, while the Medium Plus hogs are at the other side of the distribution, 133.81 and over. Although there is a wide variation about the line of averages, there is a definite tendency toward a linear relationship expressed by the formula, $y = .0125x - .52$.

It should be noted, as indicated in Table III, that this additional growth impetus which is associated with greater length is apparently obtained without any compensating influence on prolificacy or ability to raise pigs to marketable age.

CARCASS YIELD STUDIES

Basis of Calculations

Litter dressing percentages as given are based on the market weight of the litter and the "shipper" dressed carcass. Shipper dress refers to the warm carcass weight, head on, leaf lard, kidneys, and ham facings in place, after a customary cooler shrink has been deducted. The cooler shrink used in this work was 2.3%.

The term " 'packer' dressed" is used to refer to the chilled carcass ready for the cutting table, with the head, leaf lard, kidneys, and ham facings removed.

Early in the study of the experimental data it was observed that the dressing percentage, or carcass yield, of a hog exerts considerable influence on the percentages of wholesale cuts yielded by the carcass (27b). It was thought advisable, therefore, to base the percentage yield studies on the packer dressed, or chilled, carcass weight ready for the cutting table. In this way some confusing factors have been eliminated and fundamental relationships brought out more clearly.

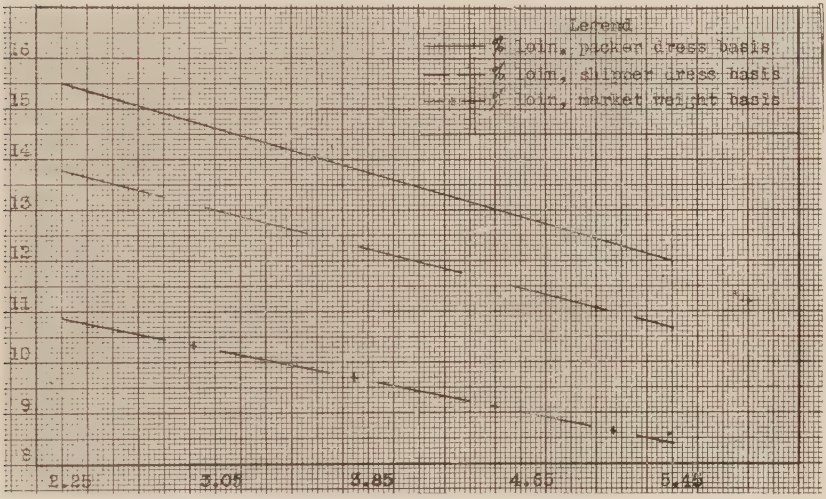
In order that the results reported herein may be thought of in terms of the shipper dressed carcass, or in terms of the market weight of the live hog, as is desirable from a commercial standpoint, lines of average relationship between each of these two items and the chilled cut carcass weight of all litters have been calculated. The results indicate that percentage figures based on the chilled, cut carcass may be converted to an approximate packer dressed basis by multiplying the percentage figures obtained on the carcass weight basis by the factor .89. Similarly, the percentage figures on the chilled carcass weight basis may be converted to a market weight basis by multiplying the percentage figure by the factor .7.

The line of average relationship between these items is based upon Tables 3 and 4, Appendix II. For example, if as in Figure 3, the line of averages for percentages of loin on a shipper carcass basis at different depths of fat, taken from Table 10, Appendix II, is given as the solid line, multiplying the points on this line by .89 would give approximately, and on the average, the corresponding percentages of loin on a warm carcass weight basis as indicated in the dashed line. Similarly, the crossed line would indicate the same points converted to a market weight basis.

Dressing Percentages

A maximum difference of 6.7% was encountered in the yield between the high and the low yielding filled litters slaughtered in this experiment. On the basis of a two-thousand-pound litter, the difference in yield would amount to 134 pounds of wholesale pork.

The first twenty-four litters slaughtered in the experiment showed an average dressing percentage of 80.40 on the basis of the unfilled market weight and the shipper dressed weight. The 68 remaining litters on the basis of the filled market



DEPTH OF FAT (cms.)

Figure 3—Trends of average litter percentage of loins at different depths of fat expressed in terms of the packer dressed carcass, the shipper dressed carcass, and the market weight of the litter.

weight and the shipper dressed weight averaged a yield of 78.40. The range of the dressing percentages in this latter group was 75.30 to 82.00 per cent.

Individual dressing percentages were calculated for each individual hog on the basis of his empty weight prior to slaughter and his shipper dressed carcass. A study of these yields showed the data to be in accord with the accepted principle that as a hog grows fatter there is an increase in his yield percentage. Tables 5 to 7, Appendix II, give the dressing percentages of the three length types of lard hogs at different depths of fat. The average trend values of the dressing percentage at 2 centimeters depth of fat were 78.20, 78.17,

and 78.34, and at 4.5 centimeters, 80.56, 80.65, and 80.55, for Medium Plus, Medium, and Medium Minus hogs, respectively. The hogs included in these three groups dressed practically identically the same at the same depth of fat. The coefficients of relationship between the depth of fat and the dressing percentage for the three groups were .301 ± .053, .301 ± .031, and .356 ± .055, respectively. The coefficients and the distributions from which they are taken verify the principle that the fatter the hog the higher his yield. They also indicate that while depth of fat is a factor in determining dressing percentage, there are other factors that contribute materially to the total variability in dressing percentages.

The Effect of the Depth of Fat on the Percentages of Wholesale Cuts

Of all the factors studied in this experiment in regard to effect upon carcass percentage yields, the depth of fat has been found to be of outstanding importance. Heretofore but little considered in this connection, the covering of fat carried by a carcass becomes a factor of major consideration whenever careful conclusions in regard to percentage yields are considered.

Before undertaking a discussion pertaining to the effect of type on percentage carcass yields, it is necessary, therefore, to discuss the influence of the depth of fat on percentage yields of hog carcasses.

In an effort to evaluate the effect of various factors, such as length of carcass, weight of carcass, and depth of fat, as determiners of the percentages of wholesale cuts that a carcass will yield, a study of the influence of these factors was made. Numerous correlations between such separate factors and percentage yields of the various cuts has brought out the fact that the covering of fat carried by a hog is a most important factor in determining the percentages of the domestic wholesale cuts that its carcass will yield.

In order to determine the influence of the depth of fat on the percentage yield of each of the wholesale cuts, Tables 8 to 11, inclusive, Appendix II, showing the distributions of the percentages of hams, bacon sides, loins, and back fat at different depths of fat, were prepared. Although the distribution characteristics show that factors other than the depth of fat are involved, the importance of that variable in its rela-

tion to percentage yields is clearly indicated. In order to illustrate the effect of the depth of fat on percentage yields and to point out the most probable yield of each wholesale cut at any particular depth of fat, Figure 4 was prepared. The lines represented in the chart showing the trends of yields of hams, bacon sides, loins, and back fat are the lines of regression resulting from a study of these data.

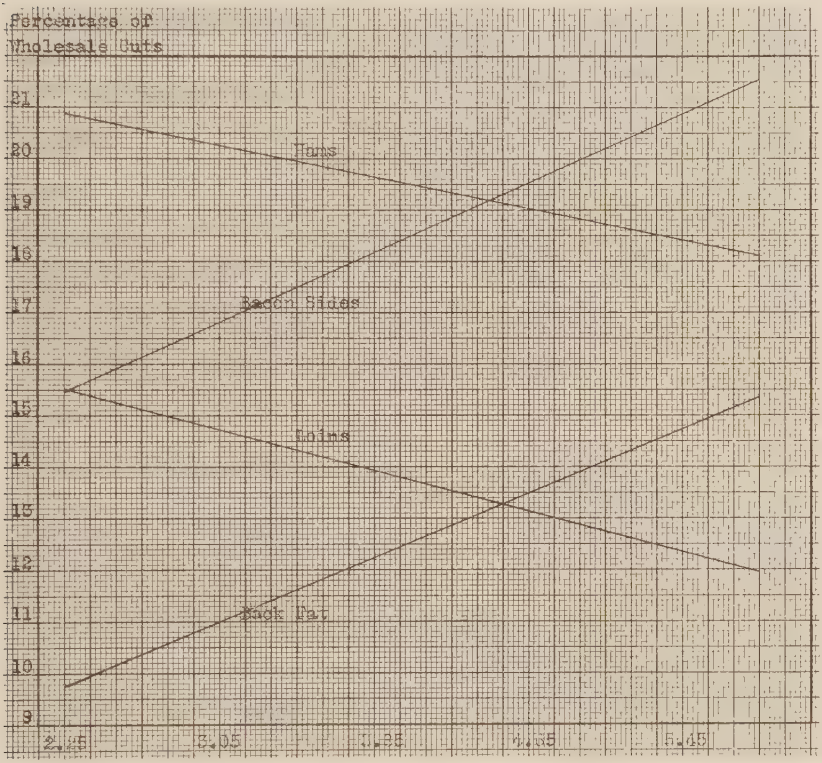


Figure 4—Trends in carcass percentages of wholesale cuts with increasing depth of fat in hogs.

The graph shows that as the depth of fat increases the percentages of the lean cuts in the carcass, the loins and the hams, decrease, while those of the fat cuts, the back fat and the bacon sides, increase. These lines of regression reveal the fact that a difference of approximately 2.7% in ham, of 5.9% in bacon sides, of 3.3% in loin, and 5.4% in fat back, is associated with an increase in the depth of fat of 3.6 centimeters,

or approximately 1.4 inches. A study of the distributions shown in the tables justifies the conclusion that such a range in depth of fat is incurred even in the so-called "good" grade of market hogs.

Supplementary studies on the effect of increasing depth of fat on percentage carcass yields were made in order to find out the effect of that factor on the yields of the smaller carcass cuts. It was found that the Boston butt, a strictly lean cut, decreased in percentage of the total, while the percentages of the shoulder fat and jowl butts increased with the depth of fat. The neck bones, spare ribs, shanks and tail, that is, the bony cuts, being a smaller proportion of the total carcass in fatter carcasses, decrease in percentage of the total.

The differences in yields as shown are sufficient to establish the fat covering as a factor which must be taken into consideration in connection with yield studies.

The Effect of Length-Type on the Yields of Lard Hog Carcasses at Different Depths of Fat

That length itself plays no part in determining percentages of wholesale cuts yielded by carcasses, except as it is associated with differences in the relative body proportions, is the conclusion indicated by the data included in this study.

Having separated the lard hogs into three type groups based upon length measurements, and having established the covering of fat as a major factor in determining the percentage yields of carcasses, an effort was made to determine the effect of length-type on percentage yields at different depths of fat. Tables 12 to 17, inclusive, Appendix II, show the distributions of the percentages of loins and of fat backs for each of the three type groups of lard hogs. The lines of regression resulting from these distribution tables are plotted in Figure 5. It will be observed that the percentages of loins decrease with increasing depth of fat for each of the three types. Similarly, an increase in percentages of fat back is shown with increasing depth of fat in accordance with data previously presented. It should be observed that the influence of length-type as a factor in determining percentage yields is a minor one in comparison with the influence of the depth of fat. Partial correlations, to be discussed later, verify this observation.

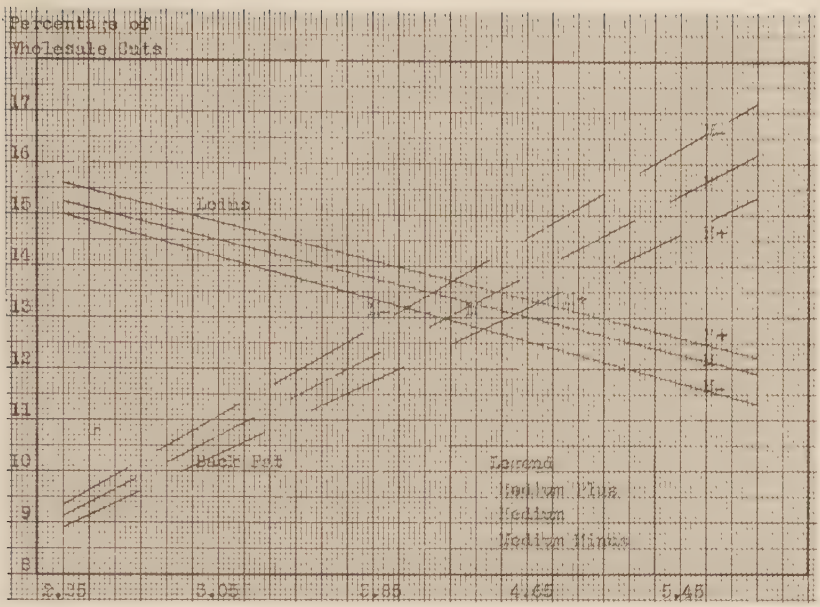


Figure 5—Trends of percentages of loins and of back fat with increasing depth of fat in different types of lard hogs.

From the diagram it will be observed that the change in percentages with increasing depth of fat occurs at different rates for each of the groups of hogs. The longer carcasses show less change with a given increase in the depth of fat than do the shorter carcasses. The percentages of loins and of fat backs for each of the three groups of carcasses are equal at approximately 13.25%. In other words, it is possible for each of these three types of lard hog carcasses to show approximately the same percentage yields of wholesale cuts. Trends and correlations on other classifications, or on limited numbers of carcasses, have verified this principle and have shown that although 13.25% is the most likely percentage at which the yield of loins and back fat are equal, a range of from 13% to 13.75% may be encountered in this value. The point at which these cuts are equal in percentages of the total carcass is reached by the three groups of hogs being discussed at different depths of fat corresponding to the differences in the average length of the carcasses in the group. The longer the carcass upon which a given fat layer is superimposed, the smaller the proportion which the fat is of the total carcass,

and, therefore, the less the effect of a given fat layer on the yields of wholesale cuts.

The difference in rate of the changes indicated in this diagram may be attributed to differences in type, but since types separated on the length basis show also a difference in relative body proportions it is well to consider this latter factor and its effect on percentage yields before drawing conclusions in regard to the direct relationship between length-type and yields.

The Dimensional Ratio

As a means of explaining differences in carcass percentage yields, and as a factor that has to do directly with determining differences in such yields, the dimensional ratio is second in importance only to the covering of fat.

The dimensional ratio, or percentage ratio of thickness in lean meat at the ham to the length of carcass from rib to aitch, is used as another type index. It represents an index of the fleshing characteristics of a hog.

Method of Calculating the Dimensional Ratio

The thickness in lean meat at the ham was obtained by subtracting two times the depth of fat measurement from the total ham thickness. The total thickness was measured from the cut surface of the aitch bone at the brim of the pelvis laterally to the side of the ham. The depth of fat measurement was taken at the butt of the ham laterally to the exposed ilium. Since the thickness of the fat layer gradually decreases from butt to shank, the thickness of the fat at the butt of the ham is not the same as it is at the side of the ham. Both measurements taken on 36 hams, however, showed the degree of relationship, or coefficient of correlation between the two, to be .858, with a standard deviation of .44 centimeters for each variable. Furthermore, the ratio of the one measurement to the other was practically the same at high and low depths of fat. It was considered satisfactory, therefore, to use the butt fat measurement for comparative purposes.

The ham thickness in lean meat was then expressed as a percentage of the length of the carcass from rib to aitch. Thus, the higher the dimensional ratio the thicker the carcass in natural fleshing in proportion to the length from rib to aitch.

Length-Type and Dimensional Ratio

The average rib-to-aitch plus aitch-to-toe measurements for the Medium Plus, Medium, and Medium Minus groups of lard hogs were 137.83, 128.85, and 118.87 centimeters, respectively. The average dimensional ratios for these groups were 25.43 ± .082, 26.09 ± .055, and 26.90 ± .108, respectively. There is an apparent tendency for the dimensional ratio to run inversely with the length measurement. A correlation between the two variables, rib-to-aitch and dimensional ratio, was used to get an expression of this relationship. Table 18, Appendix II, verifies the inverse relationship and results in a coefficient of — .368 ± .020.

In order to make a preliminary test of the influence of the dimensional ratio on percentage yields independent of the rib-to-aitch measurement, a selection of carcasses was made. For each high dimensional ratio carcass selected, there was also picked a carcass of low dimensional ratio but showing within one centimeter of the same rib-to-aitch measurement. One hundred pairs were selected for this preliminary study. The average length-type index measurements of the two groups of hogs were the same and the mean dimensional ratio of the high ratio hogs was 28.50 as compared to 23.80 for the low ratio group.

For the purpose of illustrating the results secured when straight line trends were figured through the actual percentages of hams, bacon sides, loins, and fat backs at different depths of fat, Figure 6 is presented.

The low dimensional ratio carcasses showed higher percentages of loins and bacon sides and lower percentages of hams and back fat than did the high dimensional ratio carcasses at corresponding depths of fat.

These results suggest, as do the findings of Shaw (29), that possibly extra length in swine carcasses is associated with one or more extra pairs of ribs and vertebrae, corresponding with an extra abdominal length segment. The effect on percentage yields would be to increase the carcass percentages of loins and sides and to decrease the ham and fat back percentages. This is the change represented in Figure 6.

Further, it should be noticed that the loin and back fat lines are in agreement with those presented in Figure 5, page 35. The high dimensional ratio hogs show more change with

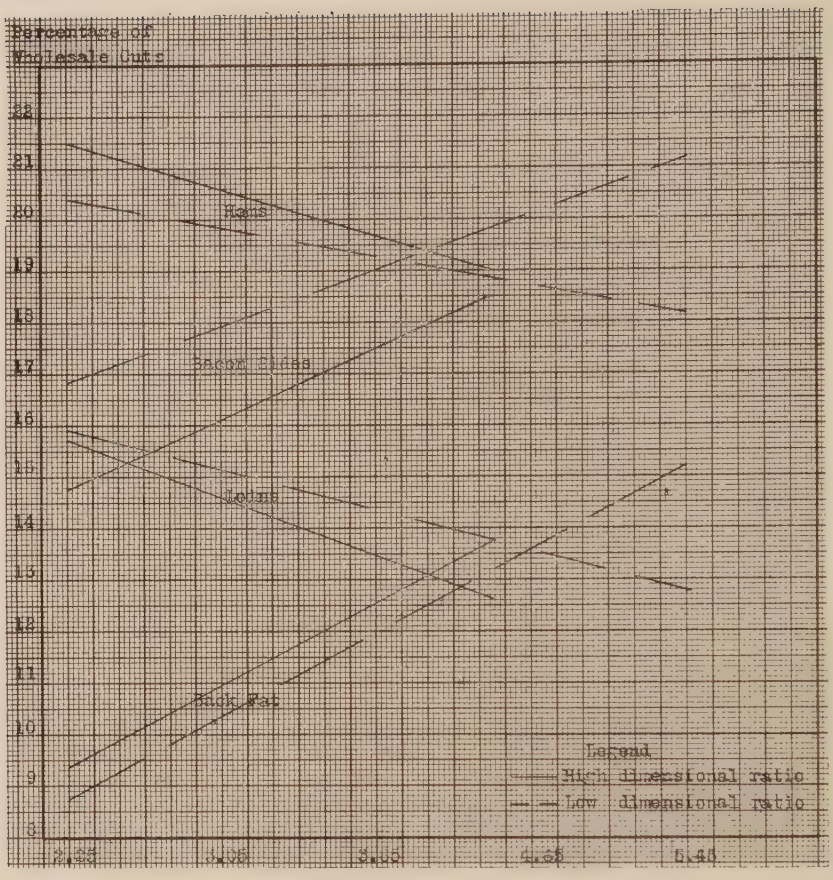


Figure 6—Lines of average relationship between carcass percentages of hams, bacon sides, loins, and back fat and the depth of fat measurements in high dimensional ratio and low dimensional ratio carcasses.

a given increase in depth of fat than is shown by the low dimensional ratio hogs.

Data from the 659 lard hog carcasses presented in Table 19, Appendix II, indicated that there was no relationship between dimensional ratio and percentage of loin. Similarly, the 861 hogs slaughtered during the first three years showed practically no correlation between the dimensional ratio and the percentage of loin, disregarding the influence of all other factors. In order to test out the factors, rib-to-aitch, dimensional ratio, and depth of fat, a little more thoroughly before proceeding with a critical analysis of the data, which could better be done only when the collection of data had been completed, a number

of correlations were run on a limited number of selected carcasses.

A correlation of —.379 ± .039 was manifested between the dimensional ratio and the percentage of loin on 223 carcasses showing the same depth of fat. In the dimensional ratio class interval, 26.00 to 26.99, 208 carcasses gave no correlation between the rib-to-aitch measurement and the percentage of ham. A small group of 61 carcasses falling in the same dimensional ratio and depth of fat class intervals showed no correlation between the rib-to-aitch and percentage of loin.

These and other simple correlations soon revealed the fact that there were interrelationships among the various independent factors themselves and that, therefore, when one independent variable is being correlated with the dependent variable, the remaining independent variables will not "average out." Apparently the method of simple correlation is inadequate for the purpose of properly evaluating the influence of these factors on the percentages of wholesale cuts that a carcass will yield. Although sub-classes may be used to eliminate multiple effects, the advantages of volume data are lost by the method. In order to determine the separate effect of each variable with the remaining independent factors varying simultaneously, the method of multiple and partial correlations was made use of.

It was decided to use only the data from strictly lard hogs for the purpose of this particular study. The independent variables included in the problem were the rib-to-aitch carcass measurement, the dimensional ratio, the depth of fat, and the carcass weight. The effect of these independent variables on two separate dependent variables—the percentage of loin and the percentage of back fat—were measured. This plan called for two separate problems dealing with these dependent variables, the one a typical lean cut, the other representative of the fat cuts. The punch card system of recording the data was employed and the data were sorted by means of mechanical tabulating equipment.

The summarized data resulting from the sorting of the coded data in these two problems are presented in Tables 20 and 21, Appendix II. From these data the final calculations were made, and the resulting coefficients are given in Table IV.

The simple correlation cofficients indicate that the depth of fat and the weight of carcass are the most important variables

studied, so far as the effect on the percentage loin yield is concerned. It should be remembered, however, that these coefficients are measures of gross relationships and may carry the effect of interrelationships.

TABLE IV—Simple, Multiple and Partial Correlations Between Certain Carcass Measurements and Percentages of Loin and Between the Same Factors and Percentages of Back Fat

x_1=percentage of loin in Problem 1 and percentage of back fat in Problem 2.
x_2=rib-to-aitch measurement. x_4=depth of fat.
x_3=dimensional ratio. x_5=weight of carcass.

Problem 1—Percentage of Loin

Subscript	Coefficients of Simple Correlation	Coefficients of Multiple Correlation	Coefficients of Partial Correlation
12	.0369	.....	—.0490
13	.0731	.....	—.2222
14	—.5040	.....	—.4172
15	—.2621	.....	.0925
		$R_{1.2345} = .5538$	

Problem 2—Percentage of Back Fat

12	.0734	.....	0
13	—.1862	.....	.1047
14	.5774	.....	.3594
15	.3931	.....	.0274
		$R_{1.2345} = .5907$	

The multiple coefficients are quite low, being only .554 and .591 for percentage of loin and of back fat, respectively. The equation of net regression, or estimating equation, for percentage of loin based upon the variables studies is: x —.0257A —.2240B — 1.4766C + .0110D + 25.79. In this equation A refers to the rib-to-aitch measurement, B to the dimensional ratio, C to the depth of fat, and D to the carcass weight. The standard error of estimate, or the standard deviation about this line of average relationship, is 1.09 in terms of percentage of loin. The interpretation to be placed upon these measures is that by inserting particular case measurements and weights into the estimating equation, one can estimate the percentage of loin to within 1.09% in 68% of the cases. It has previously been shown that the average net error in cutting, or cutting variation, is .35% of loin for the individual hog (27c).

The solution to the back fat problem gave the following regression equation: $x = -.0060A + .1710B + 2.0464C + .0051D - .1342$. The standard error of estimate for this equation is 1.8 in terms of the percentage of back fat.

The coefficients of partial correlation place the influence of the various factors studied in their proper light. The importance of the depth of fat as a factor in determining the percentages of wholesale cuts that a carcass will yield is established. The dimensional ratio, or index to the relative body proportions, is apparently of some importance in this connection, though these data would indicate that this factor plays a secondary role in determining variations in percentages of wholesale cuts. Neither the actual length from rib to aitch nor the weight of the carcass itself is shown to be of importance in determining percentage yields. The carcass weight is principally related to percentage yields not because of the weight itself, but because of the relationship between weight and depth of fat, the depth of fat being the actual determiner. The effect in this case is analogous to the one already considered wherein differences in length-type are associated with differences in yields, not because of length difference but because length is associated with a difference in body proportions as indicated by the dimensional ratio.

The Influence of the Breeding on the Dimensional Ratio

Since hogs vary in their relative body proportions, and since the body proportions influence percentage yields, the question of the influence of breeding on the dimensional ratio naturally arises. Whether or not certain breeds show different fleshing characteristics, whether these characteristics appear without much variation, and whether the parental breeds are able to transmit them to their offspring, are all questions of special interest.

In the study of the dimensional ratio, it was observed that there was a general tendency for the dimensional ratios of the individuals within the litter to show considerable variation about the average for the litter. There were, however, some litters in which there was remarkably little variation in the individual values.

Table V gives the frequency distributions of the litter average dimensional ratios by breeds.

TABLE V—Distribution of Dimensional Ratio by Breeds

(Litter Average Basis)

Dimensional Ratio	Lard Cross Bred	Duroc Jersey	Chester White	Poland China	Misc. Cross Bred	Tamworth	Hampshire	Berkshire
	f	f	f	f	f	f	f	f*
22.00 22.99		1						
23.00 23.99	1	2	1	1				
24.00 24.99	6	7						
25.00 25.99	7	7		1	6	3	2	1
26.00 26.99	11	7	6	4	8	2	2	2
27.00 27.99	8	2	2		4			
28.00 28.99	1	1		1				
29.00 29.99			1					
30.00 30.99	1							
Total.....	35	27	10	7	18	5	4	3

*One part-litter of 6 Yorkshires fell in the class, 28.00-28.99.

From the table it can be seen that there is a wide range between the high and the low dimensional ratio litters in both the lard crossbred group and the Duroc Jersey group. These two divisions of the breeding classification are the only ones that contain sufficient numbers of litters to be of much value. In the litters here studied, lard hogs, either purebred or crossbred, vary greatly in the relative body proportions shown by litters. Although litters of bacon and dual purpose breeding are not adequately represented, it is interesting to note the consistency in the values of the litter average dimensional ratios in the Tamworth, Hampshire, and Berkshire litters. Too much dependence, however, cannot be placed upon these val-

ues, as in each of these three breeds all of the litters of that breed came from the same farm and represented the same strain of breeding. Crosses between the Tamworth, Hampshire, Berkshire and Yorkshire breeds and between those breeds and hogs of strictly lard type constitute the group designated as miscellaneous cross-breds. It is an interesting observation that the litters included in that group show the same consistency in the average litter dimensional ratios as was evident for the Tamworth, Hampshire, and Berkshire litters.

The Influence of Sex on Percentage Yields

Sex, in its relation to the body form, in its influence on the growth and fattening processes of domestic meat animals, and in the difference in economic value which it effects, presents problems on which accurate data from large numbers of individuals are needed.

The data collected in this experiment offered an unusual opportunity to investigate the differences in yields between gilts and barrows. For the purpose of making such a comparison a sub-sorting of the data was made. For every barrow carcass selected, a gilt carcass of the same rib-to-aitch measurement (within .5 centimeter) was selected from the same litter. In this way the factors of breeding, rations allowed, management system, weather conditions, length from rib to aitch, and many other factors may be said to have exerted an equal influence on both groups of hogs or carcasses.

Table VI gives average weights and measurements for the two selected groups.

TABLE VI—Average Carcass Measurements, Weights and Yields of Selected Gilt and Barrow Carcasses

Sex	Number	Av. Rib to Aitch (cms.)	Av. Dimensional Ratio	Av. Depth of Fat (cms.)	Av. Liveweight* (lbs.)	Av. Dressing Percentage
Gilt	207	83.18	26.17	3.32±.038	199.78±1.323	80.04
Barrow	207	83.14	25.91	3.57±.031	209.98±1.367	79.87

* Six lightweight hogs with questionable liveweights omitted from each class.

The only significant differences brought out by the table are incurred in the depth of fat covering and in the average unfilled liveweight. The barrows showed a thicker covering of

fat and weighed practically 210 pounds as compared to 200 pounds for the gilts, a difference of ten pounds in six months.

Trends of average relationship between depths of fat and percentages of wholesale cuts for the two groups of carcasses are taken from the data in Tables 22 and 23, Appendix II. These trends are reproduced in Figures 7 and 8. The per-

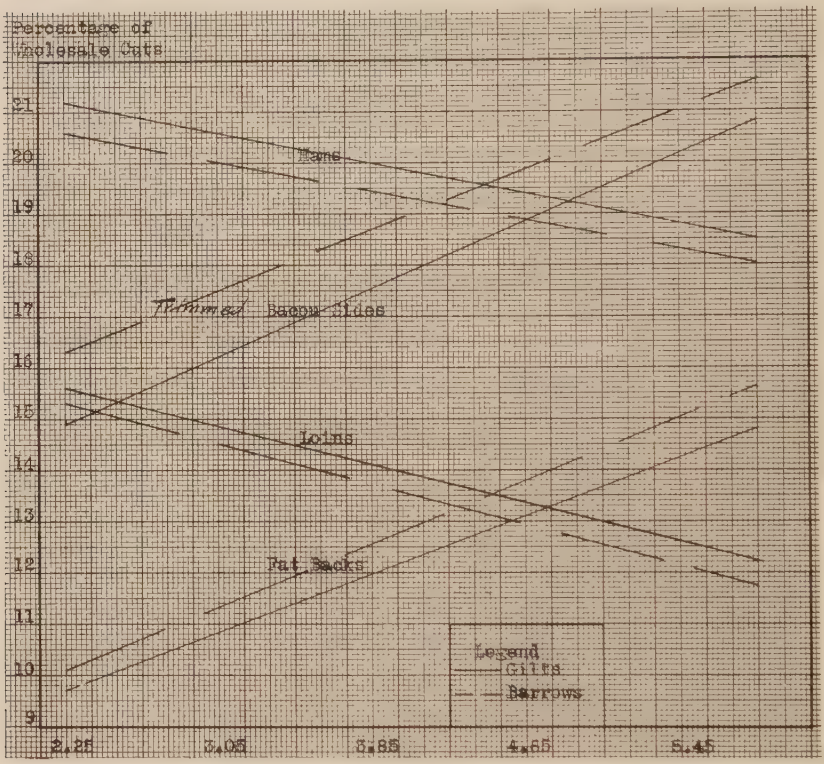
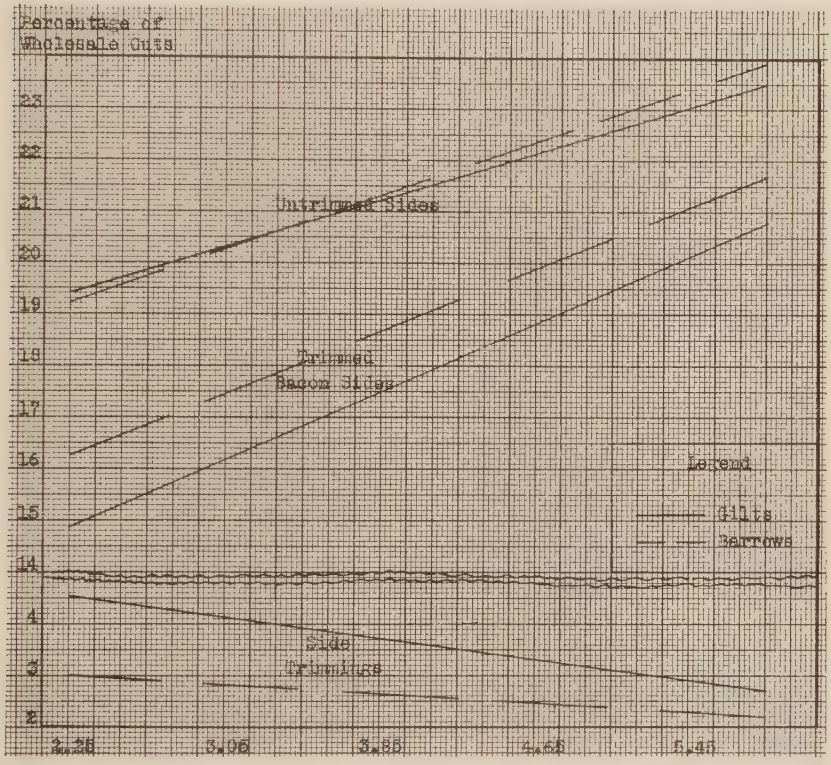


Figure 7—Showing the trends of percentages of hams, trimmed sides, loins and back fat at different depths of fat in gilts as compared to barrows.

centage yields at the same depths of fat are different for the two sexes. As brought out by Figure 7, the gilt carcasses yield more ham and loin and less trimmed bacon side and back fat than do barrows of the same depth of fat. With the exception of the percentage of trimmed sides, however, these differences are not marked.

Although it appears that the gilts were slightly thicker in proportion to length and in consequence showed higher per-

centage of lean cuts in the carcasses at the same depths of fat, there is a compensating factor in the amount of trimming necessary to insure seedless bacon sides. The glands from sow bacon sides are more likely to show discoloration or development than are the barrow glands (6). It is necessary, therefore, that the sow sides be trimmed more.



DEPTH OF FAT (cms.)

Figure 8—Depth of fat trends in percentages of untrimmed bacon sides, trimmed sides, and total side trimmings in gilt and barrow carcasses.

In Figure 8 are charted trends pertaining to bacon yields for both groups of hogs. The percentages of untrimmed bacon sides yielded by the two sexes are practically identical at the same depth of fat, as is shown by the lines of average relationship between yield of untrimmed sides and the depth of fat. The yields of trimmed sides, however, show a marked superiority for the barrows, especially at low depths of fat. The percentage of bacon sides increases rapidly as the depth of fat

increases, and, since the side is much heavier than the trimmings, the side naturally absorbs the larger part of the increase. Then too, it was observed that the amount of fat below the mammary line does not increase in direct proportion with increasing depth of fat.

Lines of trends for side trimmings indicate that at low depths of fat both gilt and barrow sides are trimmed relatively more than when they are fatter. At 2.25 centimeters depth of fat the percentage of side trimmings is 4.5 for gilts as compared to 3.00 for barrows. This difference becomes less pronounced as the depth of fat increases until at 5 centimeters the gilt carcasses yielded 3.00 percent of side trimmings and the barrow carcasses, 2.40 percent.

In order to find out whether or not these differences in yields between gilts and barrows at varying depths of fat hold also on a weight basis, Tables 24 and 25, Appendix II, giving percentages of ham at different weights for the two sexes, were set up.

The lines of regression resulting from these tables show that the packer dressed gilt carcasses yield, on the average, approximately .6% more ham at any given weight than do barrow carcasses similarly dressed. The difference at 150 pounds was .64% and at 250 pounds, .59%.

SUMMARY

QUANTITY OF PORK YIELDED BY SWINE

Within the range of length-type in lard hogs incurred in these experimental animals, the longer the type of hog the more rapid was the daily gain from farrowing to market. This additional growth impetus which is associated with greater length was apparently obtained without any compensating influence on prolificacy or ability to raise pigs to marketable age.

A range in dressing percentage of from 75.30% to 82.00% on the basis of the litter market weight and the shipper dressed carcass was incurred in the experimental litters. The data verify the principle that the fatter a hog the higher his yield, and that while the depth of fat is a factor in determining dressing percentage, there are other factors that contribute materially to the total variability in dressed yields.

The depth of fat covering on a carcass is shown to exert considerable influence in determining the percentage of wholesale cuts yielded by the carcass. The lean and the bony cuts decrease and the fat cuts increase in percentage of the total carcass as the depth of fat is increased.

Length-type in lard hogs is shown to be a factor in determining the rate of increase or decrease in percentages of wholesale cuts associated with a given increase in depth of fat. The longer the carcass upon which a given fat layer is superimposed, the less is the change in carcass yield percentages. This effect is not due, however, to length alone but rather to a change in relative body proportions which is associated with length-type to a moderate degree.

In swine, litters and individuals within the litters vary greatly in their relative body proportions, and in consequence they yield different proportions of lean to fat at given depths of fat.

Multiple and partial correlations between carcass measurements and percentages of wholesale cuts establish the importance of the depth of fat and the relative body proportions in determining the percentages of wholesale cuts that a carcass will yield, and show that neither the actual length nor the weight of the carcass are of significance in this connection.

Virgin gilts, identical in age, breeding, feeding, and management with their barrow litter mates of the same type yield slightly more of the lean cuts at given weights or depths of fat than do the barrows. On the other hand, barrow carcasses yield appreciably more trimmed sides than do gilt carcasses of the same depth of fat.

PART III

QUALITY OF PORK YIELDED BY SWINE

A consideration of equal interest to that of the quantity of pork produced by swine is the question of the influence of various factors on the quality of the pork.

That the ration plays a very important role in determining the quality of pork produced from it is a conclusion that has already been fully demonstrated (11a), (18). As was brought out in the review of literature, there is a relationship between maturity and the quality of meat in swine (10e), (30a). The authors quoted hold the theory that, owing to the composition of the fat tissue, pigs manifest soft, immature pork of inferior quality, and that as pigs mature on a ration containing only hardening feeds the fat gradually hardens until firm, quality meat results.

The data reported here seem to justify the extension of this theory to include the conception that since hogs full-fed well balanced rations mature at different rates, quality pork is reached by different types at different ages, weights, or depths of fat. In other words, some hogs mature later than others and accordingly do not yield first quality pork at comparable ages but rather only when comparable stages of development or "finish" are reached. The term, finish, as used in this report, refers to that point in the fattening processes beyond which further fattening will not result in an improvement in the quality of the pork. By maturity is meant the completion of the growth processes. The process of maturing is developmental and covers the range from conception until the body, on a protoplasmic basis, has reached a practically constant chemical composition. These two processes, finishing and maturing, parallel each other in these experimental animals and the part that each process plays in determining quantity and quality of pork is not differentiated in this work.

The Nature of the Quality Studies

Ellis and Hankins (10f) have demonstrated that soft pork has a higher content of unsaturated fatty acids than has hard fat, and also that as pigs mature, the pork becomes firmer.

In studying the quality of the pork yielded by swine, a sample of fat was removed from each experimental carcass studied in this experiment and the fat mixture was tested for its degree of unsaturation.

In the routine analysis of fats in large numbers of samples the iodine number and the refractive index have been used by most workers as an index to the character of the fat. The iodine number is a measure of the amount of iodine absorbed by a given quantity of fat and is definitely related to the degree of unsaturation present in the fatty acid mixture. The higher the iodine number, therefore, the greater the amount of unsaturation present. Increased firmness in the fat tissue would result in a lower iodine number secured from that fat. These workers also found a decrease in the refractive index with increasing hardness of the fat. Further, in agreement with Watson and Sudborough (33), they found that these two values, the iodine number and the refractive index, parallel each other to a reasonably high degree, so that for practical purposes either one alone may be used as an index to the unsaturation of the fat sample being studied. Since the refractive index lends itself readily to determination in large numbers of samples, it has been used in this work as an index of the degree of unsaturation present in the fat sample or as a measure of the firmness of the fat tissue.

Experimental Material

The experimental animals used in the quality studies were the same ones that were used in the quantity of pork investigations. These were hogs that had been full-fed well balanced rations and had made satisfactory daily gains. For the most part the litters used in these studies were fed practically the same feeds. Corn, tankage, and blue grass or clover pasture formed a combination which served as the basis of most of the rations fed. Skimmilk, reduction tankage, fish meal, semi-solid buttermilk, oats, and middlings were other feeds listed occasionally in the feed reports. Two of the litters received some soybeans, but in insufficient quantity to cause softness of pork in those litters, as was shown by the refractive indexes of their carcass fat. Four of the litters received hominy hearts and showed soft carcasses in the packing plant. These litters have not been included in the refractive index tabulations which follow because it was indicated that the ration was

the cause of the lack of quality in the pork. Since this study was designed to find out particularly the influence of the type of hog on the quality of pork yielded, only those hogs that were fed the so-called hardening rations or feeds were included in the refractive index tabulations. That the rations fed the experimental animals were not closely controlled should be taken into consideration in interpreting the results. The full feeding of a well balanced ration containing only feeds that, so far as is known at the present time, exert a hardening influence on the pork produced, is the only restriction on the rations fed to hogs included in the quality studies.

Method of Sampling the Fat

The experimental samples taken in this experiment were all removed from the same location on the fat back. A complete cross section of the fat tissue about one inch in width and three inches long was removed from the fat covering at a point adjacent to, and directly opposite, the second and third lumbar vertebrae. Care was exercised in insuring a complete cross section of the fat tissue, since it has already been shown that there is a difference in the degree of unsaturation between the internal and external layers of fat (2a). Cross sections of the fat layer were removed from the samples by means of a sharp cork borer of the correct diameter to fit inside a three-eighths inch test tube. This method of sampling insured proportionate amounts of the fat layers and facilitated the deposition of the fat tissue in the rendering vessel.

Treatment of the Samples

The samples from the first 213 hogs slaughtered in this experiment were held in refrigeration until a month after all the slaughtering for that year had been completed. They were then removed from the refrigerator, rendered, and the refractive index taken. The samples from the remainder of the carcasses were all taken in the packer cooler, placed in a thermal jug, taken directly to the State Chemist's Department, sampled, rendered, and the refractive index recorded.

Method of Rendering

A search through the literature on the subject fails to reveal exact descriptions of the method of rendering fat samples for

refractive index studies. Preliminary work showed that samples heated in three-eighths inch tubes in an open air electric oven at 110° for a period of twelve or more hours showed higher refractive indexes than did the same fat which had been subjected to a temperature of 110° for a period of only eight to ten hours, but that heating for this latter period of time caused little if any increase in the refractive index as compared to periods of shorter duration. Since it was thought advisable to render the fat until the tissue would disintegrate readily, thereby releasing all of the fat mixture, it was felt that the fat tissue should be rendered as long as possible without changing the refractive index of the fat. These experimental samples were, therefore, heated in three-eighths inch test tubes in an electric oven for a period of at least eight hours, but not to exceed ten hours.

Recently Block (2b) has reported the results of a study of the effect of the method of rendering fat samples on the resulting constants shown by the fat. He found that if the samples were rendered in wide-mouthed sample bottles, a higher refractive index and a lower iodine number were obtained as a result of oxidation. Oxidation occurred more rapidly in wide-mouthed bottles than in narrow ones. In his work Block found that in open air oven rendering, the duration of the heating period, the method of heating, and the size of the container used influenced the results obtained. He further draws the significant conclusion (2c) : "When comparing the refractive index results obtained by different workers, the methods used in rendering the fat must be known and taken into consideration."

The refractive index readings were taken with a Zeiss Butro-refractometer when the temperature of the fat was at 40° Centigrade.

Since the fat samples were taken from the same location on the carcasses, were given the same subsequent treatment, and were sampled, rendered and read under the same conditions, the refractive indexes obtained from the separate carcasses should be comparable to each other.

The Influence of the Depth of Fat on the Quality of Pork

Inasmuch as the depth of fat was shown to be the most important factor studied in regard to the quantity of pork

yielded by swine, that factor was investigated in its relation to the quality of pork. In 619 lard hog carcasses it was found that as the depth of fat increased there was a decrease in the refractive index, showing an increase in the firmness of the fat tissue. The data from which this conclusion is drawn are presented in Table 26, Appendix II. It will be observed that the degree of relationship between the depth of fat and the refractive index is fairly definite, the resulting coefficient being $-.398 \pm .023$. This would indicate, in agreement with the findings of previous workers, that the depth of fat is a factor of importance in determining firmness of pork. It also suggests that other factors besides the depth of fat were involved in determining quality, even though the hogs were all fed "hardening" rations.

The Influence of Type on the Quality of Pork Yielded by Swine

The refractive indexes of the three length-type groups of lard hogs, Medium Plus, Medium, and Medium Minus, as defined in Part II, were arranged in separate tabulations according to the depths of fat as measured on the carcasses. The coefficient of simple correlation between the depth of fat and the refractive index of the fat samples taken from the Medium Minus group of carcasses was only $-.192 \pm .058$. This coefficient is so small as to be of doubtful significance. The same correlation for the Medium Plus group of carcasses resulted in a coefficient of $-.463 \pm .047$, indicating very clearly that there was a relationship between the depth of fat and the refractive index of these carcasses. The coefficient for the Medium group of carcasses ran $-.450 \pm .028$. These data are to be found in Tables 27, 28, and 29, Appendix II. For the convenience of the reader the coefficients of simple correlation between the depth of fat and the refractive index of the fat sample for all lard hogs, and for Medium Plus, Medium, and Medium Minus lard hogs, are listed as follows:

All lard hogs	$-.398 \pm .023$
Medium Plus lard hogs	$-.463 \pm .047$
Medium lard hogs	$-.450 \pm .028$
Medium Minus lard hogs	$-.192 \pm .058$

The conclusion to be drawn from these coefficients is that although depth of fat is a factor in determining the firmness

of pork yielded by hogs, type, as determined by length measurement, is also associated with the change in firmness of pork. The Medium Minus group of hogs slaughtered in this experiment were apparently already finished before they were marketed. They had, therefore, attained optimum quality and the depth of fat was not so closely related to the quality of the fat. That length-type is a factor in determining the quality of pork that a carcass will yield is indicated by the fact that the coefficient of correlation between the variables, depth of fat and the refractive index, is materially influenced by grouping according to types. Figure 9 shows the trends of refractive indexes at increasing depth of fat for the two type groups of hogs, Medium Plus and Medium.* The trends, although taken from correlation distributions showing wide variations in the individual cases, show the average rate of hardening of the fat with increasing depth of fat. These trends also indicate that at given depths of fat within the range included here, the greater the length of the carcass the softer its fat.

Since the Medium Minus group of hogs showed little improvement with increasing depth of fat, it is suggested that there is a point in the fattening process in swine beyond which the firmness of pork does not increase by further fattening. It can be seen from Tables 28 and 29, Appendix II, that there seems to be a tendency for the data to follow the growth type of curve as the fat covering becomes thicker. It is probable then that if the range of depth of fat covering incurred in the Medium Plus and Medium type carcasses had been extended to greater depth of fat, the lines of average relationship between the depth of fat and refractive index for these two groups might be of a non-linear rather than a rectilinear form. The data secured for these two type groups do not include very fat carcasses in sufficient numbers to justify the extension of the curve to greater depths of fat. It should be recognized, however, that to the extent that there is curvilinear relationship, the coefficient of simple linear correlation, and all of the other distribution characteristics given, are influenced.

*Preliminary results previously reported (27a) showed refractive indexes uniformly higher because of a correction factor that was later found not to apply. The principle remains the same.

Grading for Physical Firmness

During the 1928 slaughter season 213 carcasses were graded on the basis of the physical firmness of the pork. The grading was performed by a committee of three persons, two representing different packing companies and the third representing the Purdue University Agricultural Experiment Station.

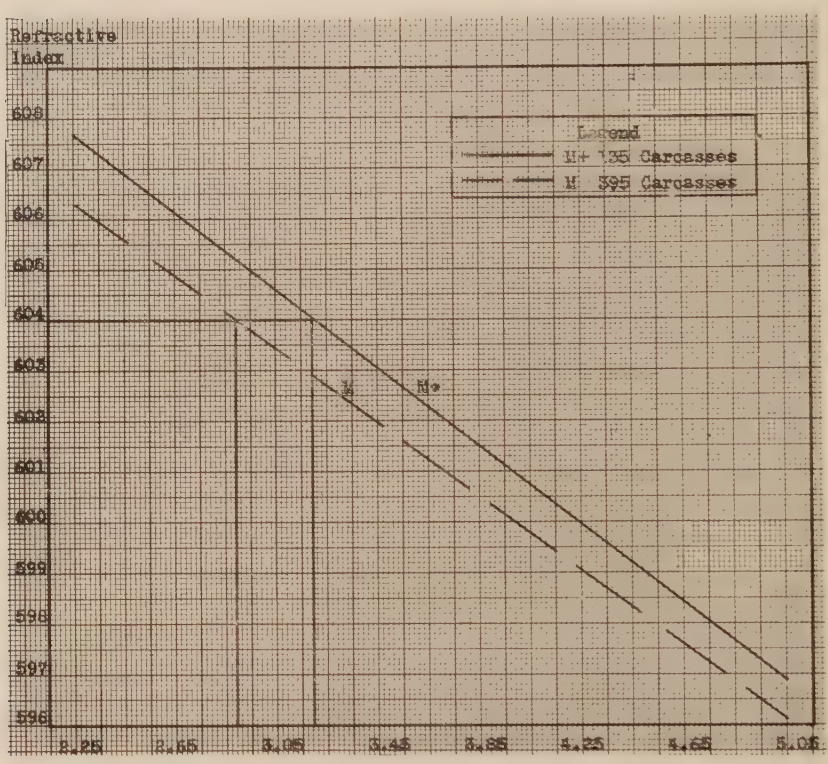


Figure 9—Trends of refractive indexes at different depths of fat—medium and medium plus hogs.

Separate gradings were made by each member of the committee. The carcasses were given a forty-five to forty-eight-hour chill and the gradings were made in the cooler while the carcasses were being held at an internal temperature of approximately 32° Centigrade. The grades used and the refractive index readings that corresponded most closely to each grade were as follows:

Hard	1.4604 and below
Medium Hard	1.4605—1.4608
Medium Soft	1.4609—1.4612
Soft	1.4613 and above

No carcasses were found to be oily.

Referring again to Figure 9, the reader will observe that the Medium group of carcasses became hard, according to the committee grading, at a depth of fat of 2.89 centimeters; that is, the point 1.4604 was reached, on the average, at that depth of fat. The Medium Plus hogs reached a corresponding degree of firmness at a depth of fat of 3.19 centimeters.

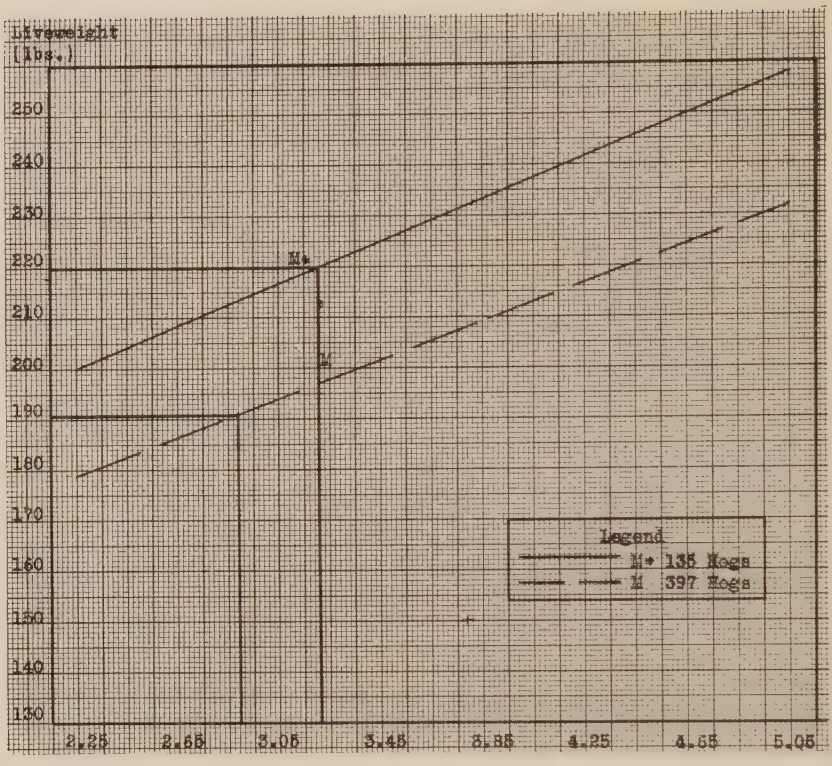
The Depth of Fat Converted to a Liveweight of Hog Basis

Correlations between the depth of fat and unfilled liveweight of the hog in the Medium Plus and Medium length-types of lard hogs are given in Tables 30 and 31, Appendix II. The lines of regression resulting from these weights are reproduced in Figure 10. The Medium Plus group of hogs became hard at a depth of fat of 3.19 centimeters, corresponding to an average liveweight of approximately 219 pounds. The Medium group became firm, on the average, at a depth of fat of 2.89 centimeters, which corresponds, on the average, to a liveweight of 191 pounds in a Medium length-type hog. The filled, or usual, market weight of these type group averages would run slightly higher than the weights given here.

That hogs are being marketed at lighter weights than formerly is a fact that should be considered in this connection. It is well to remember also, as was brought out in the review of the literature, that the so-called big type of hog has increased in numbers in breeding stock during the past decade.

The findings relating to the immaturity and the quality of pork are in agreement with those of Shutt (30b), who found that softness of pork due to immaturity was the cause of economic loss in the Canadian swine industry. A part of the variation observed by other investigators may have been due to the relative stage of maturity reached by their experimental animals when slaughtered.

The evidence at hand seems to justify the conclusion that immaturity is a factor of biologic and economic significance in connection with the soft pork problem.



DEPTH OF FAT (cms.)

Figure 10—Liveweights corresponding to different depths of fat—medium plus and medium lard hogs.

Changes in the Chemical Composition of the Fat Tissue

During the third slaughter season of this experiment the State Chemist's Department analyzed samples of fat from 207 experimental carcasses for percentages of fat, moisture, and nitrogen. Correlation distributions have been prepared showing the relationship between the depth of fat and each of several variables, the refractive index, the percentage of fat, the percentage of moisture, and the percentage of protein. The results indicate that with increasing depth of fat the percentage of fat in the fat tissue increases and the percentages of moisture and of nitrogen decrease.

The data in Table 36, Appendix II, showing the relationship between the percentage of moisture and the percentage of fat in fat tissue, indicate that there is a rather close inverse relationship between the content of these two variables in the fat

tissue. Disregarding the ration fed, the percentage of fat and the refractive index show a coefficient of correlation of —.244. These data are presented in Table 37, Appendix II.

Correlation distributions showing changes in the chemical composition of fat tissue at increasing depths of fat are presented in Tables 33 to 37, Appendix II, and from them was prepared Table VII, which helps to summarize these changes. As has already been brought out, these changes in the chemical composition of the fat tissue are accompanied by a decrease in the refractive index, indicating increased firmness of pork.

TABLE VII—Influence of Extent of Fat Covering on the Refractive Indexes and the Percentages of Fat, Moisture, and Protein in the Fat Tissue of 180-Day Old Hogs

(Readings taken from lines of average relationship)

	Depth of Fat	1.9 cms.	increased to Depth of Fat	4.7 cms.
1.	Refractive Index.....	1.4606	decreased to	1.4597
2.	Percent fat in fat tissue	91.33	increased to	94.20
3.	Percent moisture in fat tissue.....	6.37	decreased to	1.79
4.	Percent protein in fat tissue.....	1.76	decreased to	1.21

Preliminary yield tests had indicated that the fat tissue from unfinished hogs yielded less lard than the same weight of fat from well fattened hogs. Although in these analyses a difference in fat yield of approximately 2.87% is shown between hogs of 1.9 centimeters and of 4.7 centimeters, in commercial operations the difference in yield would be even greater because in the unfinished hog the skin would form a higher percentage of the total fat tissue rendered than would be the case in the fat from finished hogs.

The Dimensional Ratio and Quality of Pork

Having established that there are comparatively large variations in the relative body proportions of hogs, and having shown how variations in the relative body proportions affect percentage carcass yields, the question of the influence of the body proportions on the quality of pork was attacked.

Using the same one hundred high and one hundred low dimensional ratio carcasses selected for the quantity studies, the refractive indexes of each group were correlated to the corresponding depths of fat. These tables are given as Numbers 38 and 39, Appendix II, and graphic illustration of the results is made in Figure 11.

Apparently high dimensional ratio hogs—those that are relatively thick in lean meat in proportion to length—become firm at lower depths of fat than do the low dimensional ratio hogs. This finding is in agreement with the conclusions drawn from the quality in type studies, since the high dimensional ratio carcasses are also the shorter carcasses, corresponding to Medium Minus length-type hogs. Judging from the slopes of the two lines, or the rates at which the hardening process take place, the same improvement in quality is accompanied in high dimensional ratio hogs with less change in depth of fat. That such hogs yield a high proportion of lean to fat and at the same time finish into excellent quality pork with a minimum amount of fat is not only of biological significance but of economic importance.

Special Controlled Experiment Conducted

In order to test out the factors studied in the main experiment, and in order to study further the influence of the growth and fattening processes on the properties of fat tissue, a special experiment was carried out under controlled conditions at the Purdue University Agricultural Experiment Station. This experiment has been reviewed by Block (2b) in considerable detail, and is here reviewed briefly because of its significance in connection with the general experiment.

The plan of the experiment called for a study of four different types of hogs: namely, low dimensional ratio lard type hogs, high dimensional ratio lard type hogs, intermediate type lard hogs, and long-bodied bacon type hogs. Eighty pigs were carefully allotted into eight lots of ten pigs each. Each type was represented by two different lots, one receiving a ration containing ground corn 92.3%, tankage 7.7%, mixed and allowed in a self-feeder with a simple mineral mixture in a separate compartment, and another lot self-fed a mixture of ground corn 85.7%, ground soybeans 14.3%, and the simple mineral mixture free choice. The mineral mixture consisted of wood ashes, acid phosphate, and common salt.

Samples of fat were removed from the backs of all pigs at the beginning of the experiment and from all pigs that had made satisfactory gains each thirty days thereafter until four samples had been removed. The experiment was closed at the end of the fourth month and a fifth sample was taken from the carcasses at the packing plant.

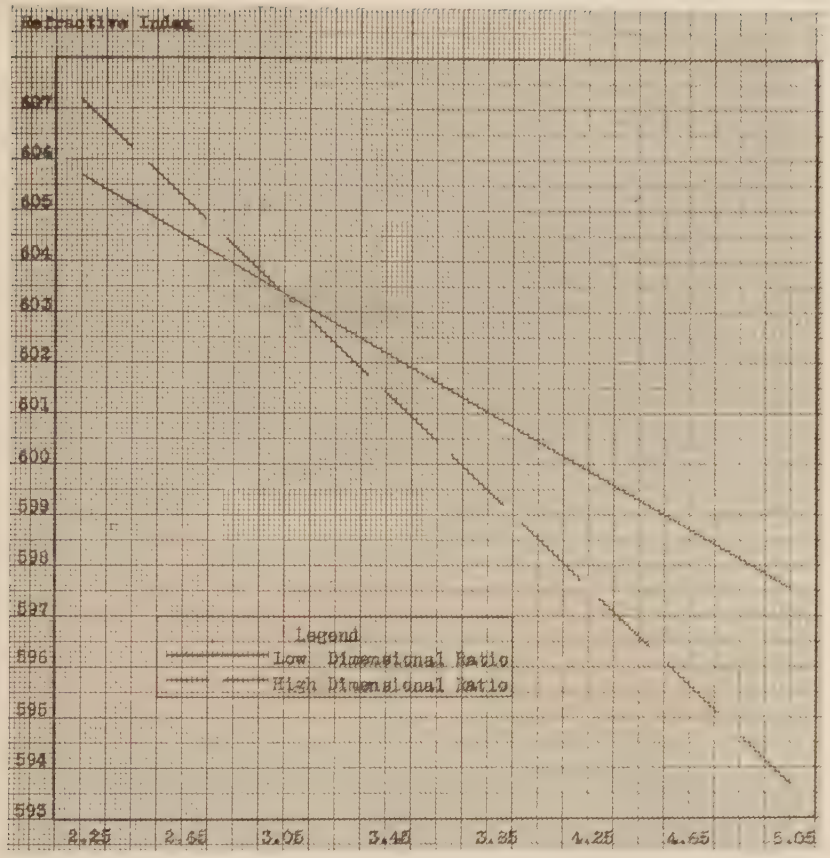


Figure 11—Trends of refractive indexes of high and low dimensional ratio hogs at different depths of fat.

The type of the hogs used in the experiment may be realized by an examination of the accompanying illustrations, Figures 12, 13, 14, and 15 showing pictures of type "representative" individuals of each of the types in the tankage fed lots.

The lots receiving ground soybeans in the ration did not make as satisfactory gains as did the corresponding lots receiving tankage as the protein supplement. The results secured in soybean lots were such that it was necessary to change the ration during the experimental period, buttermilk being added in an attempt to supply the deficient materials.

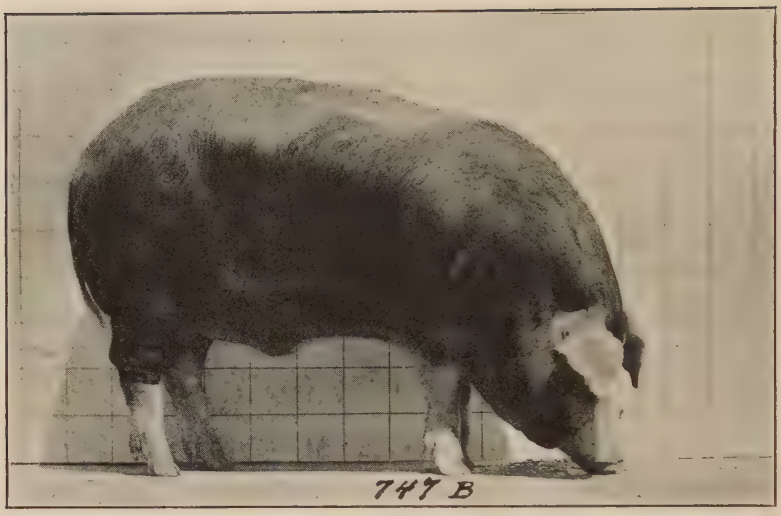


Figure 12—A type "representative" individual from the Medium Plus type, Poland, tankage fed group.

Figure 13—A type "representative" individual from the chuffy type, Poland, tankage fed group.

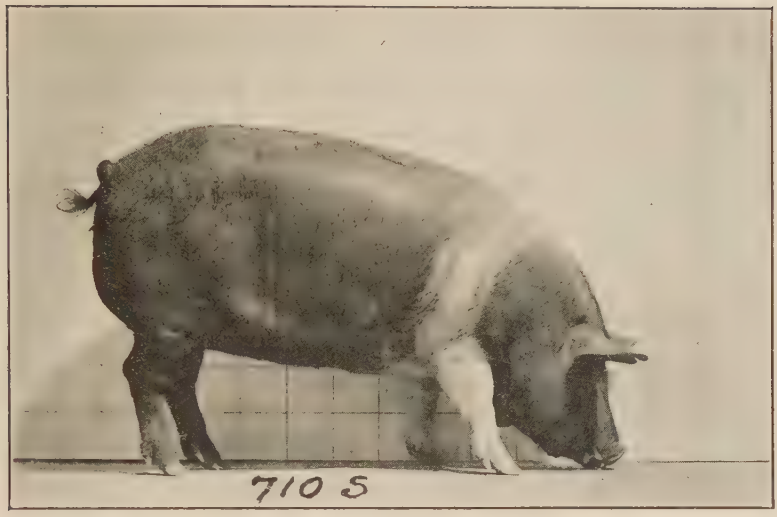


Figure 14—A type "representative" individual from the intermediate type, Hampshire, tankage fed group.

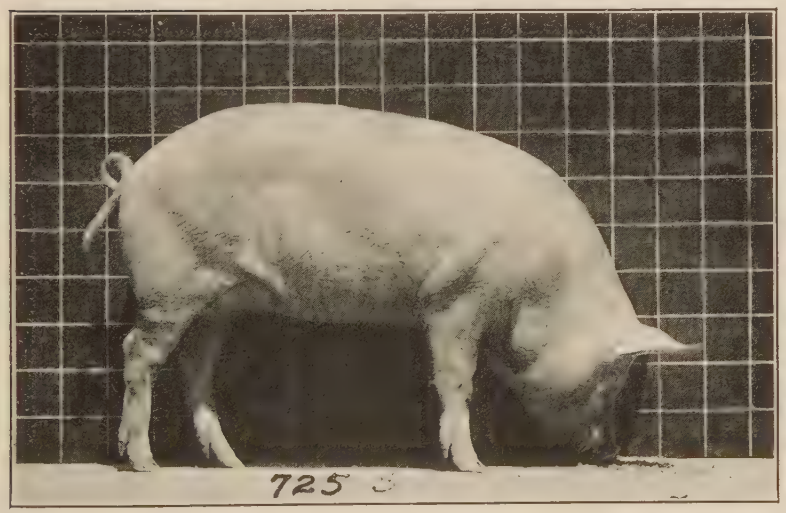


Figure 15—A type "representative" individual from the bacon type, large, Yorkshire, tankage fed group.

The results of the experiment may be summarized briefly as follows:

(1) A method of removing fat samples from live hogs was developed which permits a systematic study of the fat tissue from a given individual as the fattening process progresses. The method enables the taking of representative samples of the fat back, gives proportionate amounts of the fat layers, and is accomplished with a minimum of inconvenience to the hog.

(2) The average increase in weight of the different types of hogs studied in the experiment was, in the case of each type, proportional to the average size or weight of the individual.

(3) As the depth of fat increased, the fat content of the fat tissue increased, while the moisture and protein content in the fat tissue decreased.

(4) Hogs fed on a ration of corn, tankage, and minerals graded hard from a physical grading standpoint when the fat content of the fat tissue reached a value of approximately 93%. This relationship between percentage of fat and its firmness does not hold for hogs fed on a ration of corn and soybeans.

SUMMARY

QUALITY OF PORK YIELDED BY SWINE

There is a relationship between maturity and quality of meat in swine. Young pigs are soft in fat, and they gradually harden during the growth and fattening processes until firm, quality pork results. The data given in this manuscript show that since hogs full-fed well balanced rations do not all mature at the same time, quality pork is reached by different types at different weights and depths of fat. Each length-type of hog will yield first quality pork, but only when the proper stage of development or finish is reached.

The three length-type groups of lard hogs for which data are available showed firm pork at different weights in accordance with the length-type increase shown by the hogs. The Medium Minus, or small type hog, had already attained optimum quality before being marketed in the experiment. The Medium and Medium Plus groups became firm at average depths of fat of 2.89 and 3.19 centimeters, respectively, which corresponded to weights of 191 and 219 pounds.

These data show that maturity is a factor of importance in connection with soft pork. This is thought to be particularly true at this time, when hogs are being marketed at lighter weights and when the influence of increased length-type in the breeding stock is being felt.

As the depth of fat covering on swine increases, the percentage of fat in the fat tissue increases, and the percentages of moisture and of protein in the fat tissue decrease. These changes are accompanied by a change in the composition of the fat tissue, which results in a lowering of the refractive index and an improvement in the quality of the meat.

Hogs vary in the body proportions shown in the bony and muscular structure of the carcasses. Those hogs that have a high dimensional ratio, or are thick in lean meat in proportion to length, harden at a lesser depth of fat than do low dimensional ratio hogs. A given increase in the depth of fat of high dimensional ratio hogs effects a greater change in the quality of the pork than a corresponding increase in depth of fat gives with low dimensional ratio hogs.

A method of removing fat samples from live hogs was developed which permits a systematic study of the fat tissue from a given individual as the fattening process progresses. The method enables the taking of representative samples of the fat back, gives proportionate amounts of the fat layers, and is accomplished with a minimum of inconvenience to the hog.

APPENDIX I

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LITERATURE CITED

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APPENDIX II

CORRELATION DISTRIBUTIONS AND DATA TABLES

Nature of Data Classifications and Explanation of Symbols Used

Not all the original data recorded in the experiment are made a part of this report. Original weights of the wholesale cuts have been calculated to a percentage of the packer dressed carcass and these percentages have been checked to 100%. Such percentage figures, or other data, are presented in the form of correlation distribution tables in this appendix.

Below each distribution table are presented the measures of relationship pertaining to that distribution. Symbols used to designate the various constants and relationships are as follows:

N = number of cases.
Ma = arithmetic mean.
σ = standard deviation.
C.V. = coefficient of variation.
r = coefficient of simple correlation.
S = standard error of estimate.
R.E. = regression equation.

The classification "All Hogs" refers to all hogs slaughtered in the experiment regardless of sub-classifications. "Lard Hogs" refers only to those hogs of strictly lard breeding, as designated in Part 1, page 24.

The numbers of hogs used in the various classifications vary somewhat according to whether or not all items of data involved in the tabulation are available. Occasionally one or more hogs or litters may be omitted in the data classifications for specific reasons; such as, for example, leaving all unfilled litters out of dressing percentage tabulations, or all hominy fed hogs from the refractive index studies. In view of the volume of data available, such a limited number of omissions do not affect the results secured.

TABLE 1—Correlation Distribution Rib-to-Aitch and Aitch to Toe Measurements

Rib-to-Aitch (cms.)

Aitch to Toe (cms.)	71.00 72.99	73.00 74.99	75.00 76.99	77.00 78.99	79.00 80.99	81.00 82.99	83.00 84.99	85.00 86.99	87.00 88.99	89.00 90.99	91.00 92.99	93.00 94.99
43.00 43.99	2	1	1									
44.00 44.99	3	6	4	4	2							
45.00 45.99	1	2	5	12	5	2		1	1			
46.00 46.99		2	13	14	21	8	4					
47.00 47.99		2	8	15	30	23	9	5	4			
48.00 48.99			1	16	34	32	24	9	5	2		
49.00 49.99				7	8	32	35	20	10	5	1	
50.00 50.99			2	2	10	29	47	20	15	3	5	
51.00 51.99				1	3	10	33	30	24	8	7	
52.00 52.99						3	18	27	23	17	2	1
53.00 53.99						1	3	5	11	7	6	3
54.00 54.99							3	1	5	5	3	1
55.00 55.99										4	5	1
56.00 56.99											3	

$N = 858$

Ma_x	$= 83.55$	Ma_y	$= 49.75$
σ_x	$= 4.0520$	σ_y	$= 2.4241$
$C.V._x$	$= 4.85\%$	$C.V._y$	$= 4.87\%$

$r = .734$

P. E. $r = .4590 \times 19.57$

TABLE 2—Correlation Distribution—Length Measurement and Daily Gain—Farrowing to Market-Lard Hogs

Age-Corrected Rib-to-Aitch—Aitch-to-Toe (cms.)

Average Daily Gain (lbs.)	109 112*	112 115	115 118	118 121	121 124	124 127	127 130	130 133	133 136	136 139	139 142	142 145	145 148
.70 .75	1				1								
.76 .81	2	5	1	1		2							
.82 .87	3	2	5	2	5	2	3						
.88 .93		6	2	4	5	11	7	3	1				
.94 .99		2	6	8	14	14	20	9	3	3			
1.00 1.05	1	1	1	5	12	16	25	25	10	3			
1.06 1.11		3	1	3	10	21	17	26	12	1	1	1	
1.12 1.17			1		4	12	20	27	13	13	3	1	1
1.18 1.23				1	1	4	14	20	9	11	12	5	1
1.24 1.29					1	2	6	6	9	7	2	1	
1.30 1.35						1	3	8	4	4	2	2	
1.36 1.41						1		1	3	2	5	1	1
1.42 1.47									2	1	2	1	
1.48 1.53							1						

N = 602

Ma_x = 129.05 Ma_y = 1.09

σ_x = 6.8391 σ_y = .1384

C. $V._x$ = 5.30% C. $V._y$ = 12.70%

r = .618

(R. E.) y = .0125x — .52

*Class intervals, 109.00-111.99, etc.

TABLE 3—Correlation Distribution—Shipper Dressed Litter Weights and Packer Dressed Litter Weights

Shipper Dressed Litter Weights (lbs.)

Packer Dressed Litter Weights (lbs.)	863 987	988 1112	1113 1237	1238 1362	1363 1487	1488 1612	1613 1737	1738 1862	1863 1987	1988 2112	2113 2237
700 799	3										
800 899	5										
900 999		11									
1000 1099			7	3							
1100 1199				10	2						
1200 1299				3	11						
1300 1399					6	7	2				
1400 1499						6	8				
1500 1599							8	3			
1600 1699								3	2		
1700 1799									3	1	
1800 1899										3	
1900 1999											2

N = 109

Ma_x = 1452.52 Ma_y = 1294.04

σ_x = 306.83 σ_y = 277.75

C. $V._x$ = .21% C. $V._y$ = .21%

r = .981

(R. E.) y = .8871x + 5.51

TABLE 4—Correlation Distribution—Filled Market Litter Weights and Litter Weights Packer Dressed*

Filled Market Litter Weights (lbs.)

Packer Dressed Litter Weights (lbs.)	1150 1274	1275 1399	1400 1524	1525 1649	1650 1774	1775 1899	1900 2024	2025 2149	2150 2274	2275 2399	2400 2524	2525 2649	2650 2774
750 849	2												
850 949	3	5											
950 1049		3	2	1									
1050 1149			3	4	2								
1150 1249					7	3							
1250 1349					2	6	9						
1350 1449							7	1					
1450 1549							1	6	3				
1550 1649									2	6			
1650 1749										1	3		
1750 1849											1	2	
1850 1949													
1950 2049													1

N = 86

Ma_x = 1866.08 Ma_y = 1301.83

σ_x = 368.49 σ_y = 261.02

C. $V._x$ = .20% C. $V._y$ = .20%

r = .979

(R. E.) y = .6942x + 6.40

*24 unfilled litters omitted.

TABLE 5—Correlation Distribution—Depth of Fat and Dressing Percentage—Medium Plus Lard Hogs

Dressing %	Depth of Fat (cms.) 1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29
72.40 73.39									
73.40 74.39									
74.40 75.39		1	1		1	1			
75.40 76.39		1		2	2	1			
76.40 77.39		3	1	1	3	2			
77.40 78.39			1	5	7	1	1		
78.40 79.39	1		2	7	7	4			1
79.40 80.39		1	6	9	7	10	2	1	1
80.40 81.39	1		2	3	8	4			1
81.40 82.39				4	3	3	4	1	
82.40 83.39					1	2			
83.40 84.39		1				1			
84.40 85.39					1				1

N = 135

Ma_x = 3.43 Ma_y = 79.52

σ_x = .6098 σ_y = 1.9953

C. $V._x$ = 17.78% C. $V._y$ = 2.51%

r = .301

(R. E.) y = .9816x + 76.15

TABLE 6—Correlation Distribution—Depth of Fat and Dressing Percentage—Medium Lard Hogs

Depth of Fat (cms.)

Dressing %	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
72.40 73.39													
73.40 74.39	1			1	1	1							
74.40 75.39			4	3	2	2			1				
75.40 76.39				4	6	10			1				
76.40 77.39			3	8	4	12	4	1					
77.40 78.39		2	2	11	11	13	11	1	2	1	1		
78.40 79.39		1	1	7	16	17	11	3	3				
79.40 80.39		1	3	6	8	16	10	5		2			
80.40 81.39			2	7	13	16	16	5	1	2			
81.40 82.39			1	8	5	12	10	8	4				
82.40 83.39			1		2	10	8	4	5	1			1
83.40 84.39					4	1	1	2					
84.40 85.39						1							

N = 385

Ma_x = 3.45 Ma_y = 79.57

σ_x = .6575 σ_y = 2.2582

C. $V._x$ = 19.06% C. $V._y$ = 2.84%

r = .301

(R. E.) $y = 1.0304x + 76.02$

TABLE 7—Correlation Distribution—Depth of Fat and Dressing Percentage—Medium Minus Lard Hogs

Dressing %	Depth of Fat (cms.) 1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29
72.40 73.39						1			
73.40 74.39									
74.40 75.39									
75.40 76.39		1		2	1				
76.40 77.39		4	2	4					
77.40 78.39		1	1	2	1	2	2		
78.40 79.39		1	3	3	4	2	2	1	1
79.40 80.39	1	1	4	9	6	3		2	
80.40 81.39			2	4	5	5	3		
81.40 82.39			1	4	4	4	1	3	
82.40 83.39			1	1	1	1	3		1
83.40 84.39									
84.40 85.39							2		

N = 113

Ma_x = 3.54 Ma_y = 79.88

σ_x = .6805 σ_y = 2.0285

C. $V._x$ = 19.22% C. $V._y$ = 2.54%

r = .356

(R. E.) $y = 1.0612x + 76.12$

TABLE 8—Correlation Distribution—Depth of Fat and Percentage of Ham—All Hogs

Depth of Fat (cms.)

% Ham	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
16.50 16.99						1		1	1	3			
17.00 17.49							2	5	3			1	
17.50 17.99				2		6	9	4	3	2	3		
18.00 18.49			2		6	17	19	4	2	1			
18.50 18.99		1		4	13	20	18	12	4	4	1	1	1
19.00 19.49			2	13	17	48	33	10	6	1	3	2	3
19.50 19.99		2	5	19	40	52	31	12	3		1		2
20.00 20.49		1	4	27	44	39	35	10	4	1			
20.50 20.99		2	8	25	42	34	15	4	1		1		
21.00 21.49		4	7	28	33	25	10	6					
21.50 21.99		2	6	20	19	8	4	3	1				
22.00 22.49	1		7	5	7	3	2	1					
22.50 22.99		1	6	2	5								
23.00 23.49		1			1								

N = 996

Ma_x = 3.44 Ma_y = 19.97

σ_x = .6975 σ_y = 1.1908

C. $V._x$ = 20.18% C. $V._y$ = 5.96%

r = —.452

(R. E.) y = — .7682x + 22 61

TABLE 9—Correlation Distribution—Depth of Fat and Percentage of Bacon Side—All Hogs

Depth of Fat (cms.)

% Bacon Side	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
11.75 12.49		2	2	2		1							
12.50 13.24		1	2	2	2	1							
13.25 13.99			6	12	8	1		1					
14.00 14.74		1	7	16	11	4	3	1					
14.75 15.49	1	2	6	24	22	17	5	2					
15.50 16.24		1	4	17	31	24	10	6					
16.25 16.99			6	26	36	32	21	8	4	1			
17.00 17.74		3	6	13	36	42	33	6					
17.75 18.49		2	1	12	44	42	30	10	2	1			
18.50 19.24			1	10	22	37	30	12	4	1			
19.25 19.99		1		2	10	34	21	12	4				
20.00 20.74				1	3	10	21	9	5	3	1		
20.75 21.49				1	1	3	8	6	2	2	5		2
21.50 22.24						1	1	4	2	1	3	2	2
22.25 22.99						1	1			1	1	1	1
23.00 23.74												1	2
23.75 24.49										1			

N = 985

Ma_x = 3.456 Ma_y = 17.53

σ_x = .6958 σ_y = 2.0425

C. $V._x$ = 20.13% C. $V._y$ = 11.65%

r = .570

(R. E.) $y = 1.6732x + 11.75$

TABLE 10—Correlation Distribution—Depth of Fat and Percentage of Loin—All Hogs

Depth of Fat (cms.)

% Loin	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
10.00 10.74													1
10.75 11.49					1	1	1	3	1		1	1	2
11.50 12.24				1		5	15	14	2	2	1	1	2
12.25 12.99		1		1	10	25	35	18	11	2	4	2	2
13.00 13.74			5	16	32	65	46	16	7	5	3		
13.75 14.49			4	28	60	54	38	16	2	1			
14.50 15.24		4	8	33	48	43	19	6	2	1	1		
15.25 15.99	1	3	9	37	34	36	17	3		1			
16.00 16.74		1	9	19	24	18	10						
16.75 17.49		3	7	6	7	1	2						
17.50 18.24				2	3	3							
18.25 18.99		1			1								
19.00 19.74					1								

N = 988

Ma_y = 3.456 Ma_x = 14.33

σ_y = .7008 σ_x = 1.3820

C. $V._y$ = 20.28% C. $V._x$ = 9.64%

r = —.502

(R. E.) y = —.9860x + 17.74

TABLE 11—Correlation Distribution—Depth of Fat and Percentage of Back Fat—All Hogs

Depth of Fat (cms.)

% Back Fat	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
6.00 6.74	1	1	1	1	1	1							
6.75 7.49		5	6	4		1							
7.50 8.24			6	10	8	1	1	1					
8.25 8.99		3	9	12	21	9	2						
9.00 9.74		2	6	24	30	21	4	1					
9.75 10.49		2	5	30	48	41	15	1	1	1			
10.50 11.24			6	19	43	52	31	9	1		1		
11.25 11.99			3	20	21	47	33	9					
12.00 12.74			1	13	21	28	33	12	4	1	1		
12.75 13.49				6	12	14	30	13	6	2	3	2	4
13.50 14.24			1	2	10	21	14	9	5	4	2		
14.25 14.99				1	1	8	7	10	2	1	3	2	1
15.00 15.74					1	4	5	5	2	1			2
15.75 16.49					2	2	4		2	1			
16.50 17.24						2	4	6	2	1			
17.25 17.99								1					

N = 989

Ma_x = 3.456 Ma_y = 11.59

σ_x = .7023 σ_y = 2.0312

C. $V._x$ = 20.30% C. $V._y$ = 17.53%

r = .549

(R. E.) $y = 1.5039x + 6.39$

TABLE 12 Correlation Distribution—Depth of Fat and Percentage of Loin—Medium Plus Lard Hogs

Depth of Fat (cms.)

% Loin	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69
9.50 10.49											
10.50 11.49								2	1		
11.50 12.49							4	4			
12.50 13.49				1	2	4	8	1	1	1	1
13.50 14.49			1	6	10	12	10	1		1	
14.50 15.49		1	2	2	13	12	3	2		1	
15.50 16.49		1	1	2	3	8	2	1			
16.50 17.49			2	1	3	2	1				
17.50 18.49						1					

N = 135

Ma_x = 3.43 Ma_y = 14.43

σ_x = .6230 σ_y = 1.3803

C. $V._x$ = 18.16% C. $V._y$ = 9.57%

r = —.432

(R. E.) y = —.9500x + 17.69

TABLE 13—Correlation Distribution—Depth of Fat and Percentage of Loin—Medium Lard Hogs

Depth of Fat (cms.)

% Loin	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.69	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
9.50 10.49													
10.50 11.49						1		1					
11.50 12.49				1	2	8	11	7	7	2	1		
12.50 13.49		1	3	3	8	33	18	12	6	2			1
13.50 14.49			5	14	24	40	26	6	3	1			
14.50 15.49	1	1	7	23	27	17	7	3	1	1			
15.50 16.49		1	5	14	7	10	8						
16.50 17.49		1	1	4	5	2	1						
17.50 18.49				1	1	1							

N = 397

Ma_x = 3.39 Ma_y = 14.15

σ_x = .6635 σ_y = 1.3218

C. $V._x$ = 19.57% C. $V._y$ = 9.34%

r = —.479

(R. E.) y = —.9563x + 17.39

TABLE 14—Correlation Distribution—Depth of Fat and Percentage of Loin—Medium Minus Lard Hogs

Depth of Fat (cms.)

% Loin	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29
9.50 10.49										
10.50 11.49					1		1			
11.50 12.59					1	4	4	6	1	2
12.50 13.49				4	7	6	5	3	4	
13.50 14.49				5	16	8	7	4	1	
14.50 15.49		1	5	7	6	2	2			
15.50 16.49			2	3	2		1	1		
16.50 17.49		1	1	3						

N = 127

Ma_x = 3.34 Ma_y = 13.89

σ_x = .6968 σ_y = 1.3175

C. $V._x$ = 20.86% C. $V._y$ = 9.49%

r = — .555

(R. E.) y = —1.0588x + 17.43

TABLE 15—Correlation Distribution—Depth of Fat and Percentage of Back Fat—Medium Plus Hogs

% Back Fat	Depth of Fat (cms.) 1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69
6.00 6.74						1					
6.75 7.49		2	1	2		1					
7.50 8.24			2	1	2			1			
8.25 8.99			1		3	4					
9.00 9.74				2	6	3					
9.75 10.49			1	4	8	4	1				
10.50 11.24				1	3	8	8	5			
11.25 11.99			1	1	2	8	5	2			
12.00 12.74				1	2	2	5	1			
12.75 13.49					2	2	6		1		1
13.50 14.24					3	3	2			2	
14.25 14.99						1	1	1		1	
15.00 15.74						1					
15.75 16.49						1					
16.50 17.24									2		

N = 135

Ma_x = 3.48 Ma_y = 11.10

σ_x = .6279 σ_y = 2.0887

C. $V._x$ = 18.04% C. $V._y$ = 18.82%

r = .543

(R. E.) y = 1.7963x + 4.85

TABLE 16 -Correlation Distribution—Depth of Fat and Percentage of Back Fat—Medium Hogs

Depth of Fat (cms.)

% Back Fat	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
6.00 6.74	1	1	1	1									
6.75 7.49			4	1									
7.50 8.24				6	2		1						
8.25 8.99		1	4	6	9	4							
9.00 9.74			3	11	14	13		1					
9.75 10.49		2	3	9	16	20	10		1				
10.50 11.24			2	11	10	26	8	1					
11.25 11.99			2	8	8	19	6	2					
12.00 12.74			1	4	5	6	13	5	2	2			
12.75 13.49				2	5	4	14	5	4	1			
13.50 14.24			1		4	11	8	4	5	1			
14.25 14.99				1		3	3	4	1		1		
15.00 15.74					1	4	4	2	2	1			1
15.75 16.49						2	1	1					
16.50 17.24					1	1	4	1	1				
17.25 17.99					1	1							

N = 397

Ma_x = 3.44 Ma_y = 11.48

σ_x = .6635 σ_y = 2.1893

C. $V._x$ = 19.29% C. $V._y$ = 19.07%

r = .589

(R. E.) y = 1.9468x + 4.78

TABLE 17—Correlation Distribution—Depth of Fat and Percentage of Back Fat—Medium Minus Lard Hogs

% Back Fat	Depth of Fat (cms.) 1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29
6.00 6.74										
6.75 7.49		1	2							
7.50 8.24			3	2	1					
8.25 8.99			1	4	2	1	1			
9.00 9.74		1		1	5	3				
9.75 10.49				2	6					
10.50 11.24			1	3	4	1	3	1		
11.25 11.99			1	4	7	6	5	1		
12.00 12.74				4	3	3	3	2		
12.75 13.49				2	1	3	2		2	
13.50 14.24					1	1	3	1	1	
14.25 14.99					2	2	2	6	2	
15.00 15.74								2		1
15.75 16.49					1					1
16.50 17.24							1	1		
17.25 17.99									1	

N = 127

Ma_x = 3.39 Ma_y = 11.73

σ_x = .6895 σ_y = 2.2914

C. $V._x$ = 20.33% C. $V._y$ = 19.53%

r = .661

(R. E.) $y = 2.1934x + 4.29$

TABLE 18—Correlation Distribution—Dimensional Ratio and Rib-to-Aitch—Lard Hogs

Dimensional Ratio

Rib to Aitch (cms.)	20.00 20.99	21.00 21.99	22.00 22.99	23.00 23.99	24.00 24.99	25.00 25.99	26.00 26.99	27.00 27.99	28.00 28.99	29.00 29.99	30.00 30.99	31.00 31.99	32.00 32.99
67.00 68.99						1							
69.00 70.99													
71.00 72.99							1	3	3				
73.00 74.99						3	1	4	2	1	2		
75.00 76.99				1	3	2	1	13	10	4			
77.00 78.99			1	4	4	10	11	25	11	4	1		
79.00 80.99			2	4	12	22	37	22	9	3		1	
81.00 82.99				8	20	44	35	22	7			1	1
83.00 84.99		1	2	17	30	39	42	29	9	4	3		
85.00 86.99		1	4	9	14	29	38	16	2	2	2		
87.00 88.99	1		6	5	17	22	26	14	6		1		
89.00 90.99		2	3	8	9	12	12	4		2			
91.00 92.99		5	2	2	7	11	4		1				
93.00 94.99			2	1	1	1			1				

N = 857

Ma_x = 26.08 Ma_y = 83.20

σ_x = 1.6126 σ_y = 4.4262

C. $V._x$ = 6.18% C. $V._y$ = 5.32%

r = —.368

(R. E.) x = —.1341y + 37.24

TABLE 19—Correlation Distribution—Dimensional Ratio and Percentage of Loin—Lard Hogs

Dimensional Ratio

% Loin	21.00 21.99	22.00 22.99	23.00 23.99	24.00 24.99	25.00 25.99	26.00 26.99	27.00 27.99	28.00 28.99	29.00 29.99	30.00 30.99	31.00 31.99	32.00 32.99
9.50 10.49												
10.50 11.49			1	1	3	1	1					
11.50 12.49		1	5	12	18	16	9	2				
12.50 13.49		5	11	18	37	29	23	9	1	2		
13.50 14.49		4	11	24	45	51	43	17	5	1		
14.50 15.49	1	4	11	24	26	34	25	9	6	3	1	1
15.50 16.49		3	7	12	13	13	12	6	4	2	1	
16.50 17.49			4	6	5	5	4	3	1			
17.50 18.49					2	2						

$N = 659$

$Ma_y = 14.17$ $\quad Ma_x = 26.10$

$\sigma_y = 1.3446$ $\quad \sigma_x = 1.6746$

$C.V._y = 9.49\%$ $\quad C.V._x = 6.42\%$

$r = .064$

TABLE 20—Summarized Coded Data—Multiple Correlation Between Carcass Weights and Measurements and the Percentage of Loin in the Carcass

x_1 = percentage of Loin
x_2 = rib-to-aitch length
x_3 = dimensional ratio
x_4 = depth of fat
x_5 = weight of carcass
N = 861 carcasses

	x_1	x_2	x_3	x_4	x_5
Ma	13.8464	14.7661	11.6998	13.4223	13.6108
$\Sigma x_1(x_n)$	125646	117608	93767	99716	104456
$\Sigma x_2(x_n)$	.....	134503	94850	115347	122135
$\Sigma x_3(x_n)$	.....	.....	88922	84468	88465
$\Sigma x_4(x_n)$	.....	.....	.....	114679	111833
$\Sigma x_5(x_n)$	.....	.....	.....	.....	117651
σ_x	5.2493	4.0862	4.2780	4.4698	4.4800
p1.2..5	.....	.7922	1.6421	—11.8261	—6.1639
Regression Coefficients	.....	—.1026	—.3584	—.8855	.2191
Coding Formulae	4(x—10.88)	(A-68)	2.5(B-21.54)	6.67(C-1.5)	.2(D-90)

TABLE 21—Summarized Coded Data—Multiple Correlation Between Carcass Weight and Measurements and the Percentage of Back Fat

x_1 = percentage of Back Fat
x_2 = rib-to-aitch length
x_3 = dimensional ratio
x_4 = depth of fat
x_5 = weight of carcass
N = 861 carcasses

	x_1	x_2	x_3	x_4	x_5
Ma	13.9721	14.7661	11.6998	13.4223	13.6108
$\Sigma x_1(x_n)$	129778	119179	91116	115729	114611
$\Sigma x_2(x_n)$	.....	134503	94850	115347	122135
$\Sigma x_3(x_n)$	.....	.....	88922	84468	88465
$\Sigma x_4(x_n)$	.....	.....	.....	114679	111833
$\Sigma x_5(x_n)$	.....	.....	.....	.....	117651
σ_x	5.5919	4.0862	4.2780	4.4698	4.4800
p1.2..5	.....	1.6778	—4.4551	14.4326	9.8476
Regression Coefficients	.....	—.0151	.1710	.7670	.0642
Coding Formulae	2.5(x-6.26)	(A-68)	2.5(B-21.54)	6.67(C-1.5)	.2(D-90)

TABLE 22—Trends of Wholesale Cuts at Different Depths of Fat
Gilts

Midpoint of Class Interval	Frequency	Total % Hams	Total % Untrimmed Sides	Total % Trimmed Sides	Total % Loins	Total % Back Fat
1.45	1	22.00	18.52	14.76	15.25	6.26
1.85	5	105.25	96.18	81.99	83.08	39.45
2.25	15	325.32	294.01	229.50	231.04	139.25
2.65	38	789.99	748.88	586.08	585.44	396.49
3.05	48	999.50	976.30	768.19	709.12	509.44
3.45	45	906.65	939.39	764.21	648.96	512.35
3.85	32	620.73	678.11	540.43	438.50	414.43
4.25	5	97.77	107.05	84.58	69.53	63.70
4.65	8	154.17	178.71	156.12	107.58	105.87
5.05	2	37.97	47.73	44.21	26.81	26.49
5.45	3	57.26	70.85	65.49	38.35	39.07
5.85	3	57.63	71.05	66.52	34.90	43.12
6.25	2	40.40	45.09	41.87	27.20	21.89
Total.....	207	4214.64	4271.87	3443.95	3015.76	2317.82

Straight Line Trends

Hams.....y = 22.84 — .748x
Untrimmed sides.....y = 16.86 + 1.141x
Trimmed sides.....y = 11.21 + 1.64x
Loins.....y = 17.67 — .937x
Back fat.....y = 6.64 + 1.3766x

TABLE 23—Trends of Wholesale Cuts at Different Depths of Fat
Barrows

Midpoint of Class Interval	Frequency	Total % Hams	Total % Untrimmed Sides	Total % Trimmed Sides	Total % Loins	Total % Back Fat
2.25	6	122.46	116.58	100.35	93.71	57.63
2.65	18	366.71	354.54	304.43	267.63	191.56
3.05	42	841.67	845.37	726.74	609.27	484.89
3.45	62	1226.48	1294.51	1121.33	879.26	714.64
3.85	41	785.71	878.25	765.00	568.13	530.61
4.25	20	387.85	440.73	388.93	257.60	268.49
4.65	6	108.65	129.78	113.87	74.42	91.03
5.05	6	108.15	135.38	121.39	78.55	86.32
5.45	4	74.65	93.54	86.38	49.96	55.24
5.85	2	38.87	47.42	43.86	24.04	26.37
Total.....	207	4061.20	4336.10	3772.36	2902.57	2506.78

Straight Line Trends

Hams.....y = 22.22 — .731x
Untrimmed sides.....y = 16.41 + 1.274x
Trimmed sides.....y = 12.92 + 1.487x
Loins.....y = 17.59 — 1.001x
Back fat.....y = 6.64 + 1.536x

TABLE 24—Correlation Distribution—Liveweight and Percentage of Ham —Sows

% Ham	Liveweight (lbs.) 133 145*	145 157	157 169	169 181	181 193	193 205	205 217	217 229	229 241	241 253	253 265	265 277	277 289	289 301
16.50 16.99														
17.00 17.49														
17.50 17.99						2	1	3						
18.00 18.49				1		1	3	1	1					
18.50 18.99				3	2	5	1	2	1	1		1		
19.00 19.49			1	3	3	3	5	4	5		1		2	
19.50 19.99		1	1	1	5	2	6	3	3					1
20.00 20.49	1	1	2	4	5	6	2	1	2	1	2			
20.50 20.99		2	3	7	4	5	4	4	1		1			
21.00 21.49		2	3	7	6	5	4		3			1		
21.50 21.99		1	1	3	3	4	3	1						
22.00 22.49		1	1		2	3				1				
22.50 22.99			3		1	2		1						
23.00 23.49			1		1									

N = 201

Ma_x = 199.48 Ma_y = 20.34

σ_x = 27.8112 σ_y = 1.2239

C. $V._x$ = 13.94% C. $V._y$ = 6.02%

r = —.301

(R. E.) y = —.0132x + 22.97

* Class intervals, 133.00 — 144.99, etc.

TABLE 25—Correlation Distribution—Liveweight and Percentage of Ham—Barrows

Liveweight (lbs.)

% Ham	133 145*	145 157	157 169	169 181	181 193	193 205	205 217	217 229	229 241	241 253	253 265	265 277	277 289
16.50 16.99								2		1	1		
17.00 17.49							1	4	1				
17.50 17.99					1	1	1		1	1	1		
18.00 18.49				1	3	3	3	1	3	1	2		2
18.50 18.99				1		7	5	4	4	1	1	2	
19.00 19.49		1	1	5	2	6	7	3		3	1	2	1
19.50 19.99		1	2	3	5	6	5	6	2	4	1		
20.00 20.49			2	5	4	4	4	6	5	1			
20.50 20.99	1	1	1	4	1	3	4	4	2		1		
21.00 21.49			1	3	1	2	3	1	1	1	1		
21.50 21.99			1			2							
22.00 22.49		1			1	1		1					
22.50 22.99													
23.00 23.49													

N = 201

Ma_x = 210.64 Ma_y = 19.58

σ_x = 28.2732 σ_y = 1.1499

C. $V._x$ = 13.42% C. $V._y$ = 5.87%

r = —.309

(R. E.) y = —.0126x + 22.23

* Class intervals, 133.00 — 144.99, etc.

TABLE 26—Correlation Distribution—Depth of Fat and Refractive Index
All Lard Hog Carcasses

Depth of Fat (cms.)

Refractive Index	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
* 589 591							2		1				
592 594			1	1	4	5	2	4	4	3			
595 597				3	18	26	22	12	9	4			1
598 600		1	5	17	32	40	32	23	7	3			
601 603		1	6	11	21	37	27	7	3	2	1		
604 606		1	10	22	26	21	14	2					
607 609	1	3	5	14	14	18	10						
610 612		1	4	10	8	9	2	1	1				
613 615		1	1	6	4	3	1						
616 618				1	2	1	1						
619 621				2									
622 624			1										

N = 619

Ma_x = 2.78 Ma_y = 602.04

σ_x = .6653 σ_y = 5.3817

C. $V._x$ = 23.93% C. $V._y$ = .89%

r = —.398

(R. E.) y = 3.1978x + 593.15

* 1.4.....omitted from refractive index readings.

TABLE 27—Correlation Distribution—Depth of Fat and Refractive Inde : —Medium Plus Lard Hog Carcasses

Depth of Fat (cms.)

Refractive Index	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
589 591							1						
592 594						1			1	1	1		
595 597					1	1	5	1	1	2			
598 600				2	7	11	10	5					
601 603			1	2	5	5	5	2					
604 606		1	3	2	4	7	2						
607 609		1	2	3	6	6	4						
610 612				1	2	6	1	1					
613 615		1		1		1							
616 618					1								
619 621													
622 624													

N = 127

Ma_x = 3.46 Ma_y = 602.93

σ_x = .6432 σ_y = 5.3067

C. $V._x$ = 18.59% C. $V._y$ = .89%

r = — .463

(R. E.) y = —3.7952x + 616.06

TABLE 28—Correlation Distribution—Depth of Fat and Refractive Index —Medium Lard Hog Carcasses

Depth of Fat (cms.)

Refractive Index	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
589 591							1		1				
592 594			1		1	4	1	4	2	1			
595 597				1	10	18	14	9	8	2			1
598 600			2	9	18	24	18	11	4	3			
601 603		1	3	8	10	28	18	3	1		1		
604 606		1	4	14	15	12	8	2					
607 609	1	1	3	8	6	6	7						
610 612		1	2	7	4	4	1		1				
613 615			1	5	4	2	1						
616 618				1	1								
619 621				2									
622 624			1										

N = 367

Ma_x = 3.45 Ma_y = 601.97

σ_x = .6718 σ_y = 5.5188

C. $V._x$ = 19.47% C. $V._y$ = .86%

r = — .450

(R. E.) y = —3.6967x + 614.72

TABLE 29—Correlation Distribution—Depth of Fat and Refractive Index —Medium Minus Lard Hog Carcasses

Depth of Fat (cms.)

Refractive Index	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
589 591													
592 594				1	3	1	1						
595 597				3	6	7	5	2					
598 600		1	3	4	8	2	4	8	4				
601 603				3	4	3	4	3	2	2			
604 606			3	5	7	4	3	1					
607 609		1		4	1	3	2						
610 612			2	2	1								
613 615													
616 618					1		1						
619 621													
622 624													

N = 125

Ma_x = 3.39 Ma_y = 601.34

σ_x = .6940 σ_y = 4.9164

C. $V._x$ = 20.47% C. $V._y$ = .82%

r = — .192

(R. E.) y = —1.3460x + 605.90

TABLE 30—Correlation Distribution—Carcass Depth of Fat and Live weight of Hog—Medium Plus Lard Hogs

Depth of Fat (cms.)

Weight (lbs.)	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09
145.00 156.99												
157.00 168.99												
169.00 180.99		1			2	1						
181.00 192.99			1	3	4	3						
193.00 204.99		1	1	2	1	4	2					
205.00 216.99			2	3	9	4	4					
217.00 228.99			3	3	8	14	4			1		
229.00 240.99				1	1	9	6	2		1		
241.00 252.99				1	5	3	4	3	1	1		
253.00 264.99					1		5	2	1	1		
265.00 276.99						1	2					
277.00 288.99						1	2					
289.00 300.99												

N = 135

Ma_x = 3.43 Ma_y = 225.12

σ_x = .6098 σ_y = 24.5652

C. $V._x$ = 17.78% C. $V._y$ = 10.91%

r = .507

(R. E.) y = 20.54x + 154.67

TABLE 31—Correlation Distribution—Carcass Depth of Fat and Live-weight of Hog—Medium Lard Hogs

Depth of Fat (cms.)

Weight (lbs.)	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
133.00 144.99			1										
145.00 156.99	1		2	1	1								
157.00 168.99		1	3	11	5	4	1						
169.00 180.99		1	4	12	16	10	8	1					
181.00 192.99		1	6	17	18	20	3	2	1				
193.00 204.99			2	9	15	27	18	4	2	1			
205.00 216.99		1	2	3	9	26	17	3	2				
217.00 228.99				3	6	14	15	8	5	1			
229.00 240.99			1	3	3	6	5	7	5	2	1		
241.00 252.99				1			4	4	2	1			
253.00 264.99					2	2	1			1			
265.00 276.99						1							
277.00 288.99													1
289.00 300.99													
301.00 312.99						1							

N = 397

Ma_x = 3.44 Ma_y = 201.81

σ_x = .6639 σ_y = 24.5328

C. $V._x$ = 19.30% C. $V._y$ = 12.16%

r = .511

(R. E.) $y = 18.84x + 137.00$

TABLE 32—Correlation Distribution—Carcass Depth of Fat and Live-weight of Hog—Medium Minus Lard Hogs

Depth of Fat (cms.)

Weight (lbs.)	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
121.00 132.99		1											
133.00 144.99			1			1							
145.00 156.99		1	3	4	1		1						
157.00 168.99			3	4	3	2	1						
169.00 180.99			2	5	10	6	2						
181.00 192.99			1	2	8	7		5					
193.00 204.99				3	9	6	8						
205.00 216.99				1	1	1	3	3	2	1			
217.00 228.99				1			2	4	1	1			
229.00 240.99					1		1	1	2				
241.00 252.99									1				

N = 127

Ma_x = 3.37 Ma_y = 187.76

σ_x = .6899 σ_y = 23.41

C. $V._x$ = 17.38% C. $V._y$ = 12.47%

r = .647

(R. E.) $y = 22.05x + 113.45$

TABLE 33—Correlation Distribution—Depth of Fat and Percentage of Fat

Depth of Fat (cms.)

% Fat	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
88.00 88.49			1										
88.50 88.99	1												
89.00 89.49						1							
89.50 89.99			2										
90.00 90.49			1	1	1	2							
90.50 90.99		1	3	1	3	1							
91.00 91.49			1	2		2		2					
91.50 91.99			3	5	3	2	4						
92.00 92.49			2	5	9	5	3	2					
92.50 92.99			1	3	8	9	4	1	1				
93.00 93.49				7	11	15	10						
93.50 93.99				6	6	6	9	6	2				
94.00 94.49					3	4	5	5	2				
94.50 94.99						4	6	2	1				

N = 207

Ma_x = 3.38 Ma_y = 92.85

σ_x = .6181 σ_y = 1.2347

C. $V._x$ = 18.29% C. $V._y$ = 1.33%

r = .513

(R. E.) $y = 1.0248x + 89.39$

TABLE 34—Correlation Distribution—Depth of Fat and Percentage of Moisture

Depth of Fat (cms.)

% Moisture	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
3.50 3.99					1	2	3						
4.00 4.49			1	3	5	3	4	4	3				
4.50 4.99			2	6	9	8	13	9	2				
5.00 5.49			1	5	14	11	13	1					
5.50 5.99				8	7	17	3	2	1				
6.00 6.49			2	4	2	4	5	1					
6.50 6.99		1	3	3	4	3		1					
7.00 7.49		1	1		2	1							
7.50 7.99			2	1		2							
8.00 8.49			1										
8.50 8.99	1		1										

N = 207

Ma_x = 3.38 Ma_y = 5.42

σ_x = .6181 σ_y = .9483

C. $V._x$ = 18.29% C. $V._y$ = 17.50%

r = —.415

(R. E.) y = —.6367x + 7.572

TABLE 35—Correlation Distribution—Depth of Fat and Percentage of Protein

Depth of Fat (cms.)

% Protein N_x 5.55	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
.85 .99					2		2	1					
1.00 1.14				1		7	3	4	2				
1.15 1.29				4	11	11	12	1	2				
1.30 1.44			1	3	5	8	12	6	2				
1.45 1.59			2	8	7	12	6	1					
1.60 1.74			4	7	6	8	4	2					
1.75 1.89			2	1	8								
1.90 2.04			2		1	2							
2.05 2.19		1	1	1	1								
2.20 2.34			1	1		1							
2.35 2.49					1								
2.50 2.64	1												
2.65 2.79													

N = 192

Ma_x = 3.39 Ma_y = 1.47

σ_x = .6064 σ_y = .2957

C. $V._x$ = 1.789% C. $V._y$ = 20.12%

r = —.404

(R. E.) y = —.1970x + 2.14

TABLE 36—Correlation Distribution—Percentage of Moisture and Percentage of Fat

Percentage of Moisture

% Fat	3.50 3.99	4.00 4.49	4.50 4.99	5.00 5.49	5.50 5.99	6.00 6.49	6.50 6.99	7.00 7.49	7.50 7.99	8.00 8.49	8.50 8.99
88.00 88.49									1		
88.50 88.99											1
89.00 89.49									1		
89.50 89.99										1	1
90.00 90.49							2	1	2		
90.50 90.99				1			4	4	1		
91.00 91.49					1	2	4				
91.50 91.99		1	1	1	2	10	2				
92.00 92.49			2	5	12	4	3				
92.50 92.99		1	3	8	13	2					
93.00 93.49		2	9	24	8						
93.50 93.99	2	4	23	4	2						
94.00 94.49	1	8	9	1							
94.50 94.99	3	7	2	1							

N = 207

Ma_x = 5.42 Ma_y = 92.85

σ_x = .9547 σ_y = 1.2347

C. $V._x$ = 17.61% C. $V._y$ = 1.33%

r = —.867

(R. E.) x = —.6727y + 67.88

TABLE 37—Correlation Distribution—Refractive Index and Percentage of Fat

Refractive Index

% Fat	589* 591	592 594	595 597	598 600	601 603	604 606	607 609	610 612	613 615	616 618
88.00 88.49										1
88.50 88.99							1			
89.00 89.49					1					
89.50 89.99						2				
90.00 90.49			1		3		1			
90.50 90.99				2	1	5	1	1		
91.00 91.49			2	1	2	1			1	
91.50 91.99			3	6	3	4	1			
92.00 92.49			2	6	8	4	3	2	1	
92.50 92.99			5	7	10	3		2		
93.00 93.49		1	8	12	9	4	5	1	1	2
93.50 93.99		1	10	9	11	2	1		1	
94.00 94.49			11	3	2	2	1			
94.50 94.99			1	4	4	2	1		1	

N = 207

Ma_x = 601.957 Ma_y = 92.85

σ_x = 4.8168 σ_y = 1.2347

C. $V._x$ = .80% C. $V._y$ = 1.32%

r = —.244

(R. E.) x = —.9519y + 689.95

*1.4.....omitted from refractive index readings.

TABLE 38—Correlation Distribution—Depth of Fat and Refractive Index—High Dimensional Ratio Hogs

Refractive Index	Depth of Fat (cms.)										
	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69
1.4589 591											
592 594			1	1	2	2	1				
595 597				2	6	4	1	1			
598 600		1	1	3	6	4	1	1			
601 603			1	1	5	4	1				
604 606			1	5	6	4	1				
607 609			4	5	4	2					
610 612			3	5	1	2					
613 615				2	1						
616 618			1		1						
619 621				2							

N = 100

Ma_x = 3.04 Ma_y = 603.44

σ_x = .4746 σ_y = 6.4269

C. $V._x$ = 15.61% C. $V._y$ = 1.07%

r = — .357

(R. E.) y = —4.87x + 618.24

TABLE 39—Correlation Distribution—Depth of Fat and Refractive Index—Low Dimensional Ratio Hogs

Depth of Fat (cms.)

Refractive Index	1.30 1.69	1.70 2.09	2.10 2.49	2.50 2.89	2.90 3.29	3.30 3.69	3.70 4.09	4.10 4.49	4.50 4.89	4.90 5.29	5.30 5.69	5.70 6.09	6.10 6.49
1.4589 591													
592 594								1	1	3			
595 597					2	6	6	3	2	2			1
598 600					1	3	5	6	3	2			
601 603				2	4	6	11	2	2	1	1		
604 606			1	2	3	3	4						
607 609					2	1	3						
610 612					1			1					
613 615					1	2							
616 618													

N = 100

Ma_x = 3.89 Ma_y = 600.92

σ_x = .6904 σ_y = 4.6770

C. $V._x$ = 17.75% C. $V._y$ = .78%

r = — .430

(R. E.) y = —2.91x + 612.24